Significant Habitats: Atlantic Coast Initiative (SHACI) Halifax Regional Municipality – Units 4-6

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2005

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2724

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106-00661/

Canadian Manuscript Report of
Fisheries and Aquatic Sciences xxxx

2005

SIGNIFICANT HABITATS: ATLANTIC COAST INITIATIVE(SHACI)
HALIFAX REGIONAL MUNICIPALITY – UNITS 4-6

by

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Cat. No. Fs 97-4/2724 ISSN 0706-6473

Correct citation for this publication:

McCullough, D.M., P.A. Doherty, H.L. Schaefer, C. Deacoff, S.K. Johnston, D.R. Duggan, B.D. Petrie and V.V. Soukhovtsev. 2005. Significant Habitats: Atlantic Coast Initiative (SHACI). Halifax Regional Municipality - Units 4-6. Can. Manuscr. Rep. Fish. Aquat. Sci. 2724: xvii + 501 pp.

Table of Contents

LIST OF FIGURES VI
ACKNOWLEDGEMENTS XIV
ABSTRACT XVI
RÉSUMÉ XVII
1 – SHACI INTRODUCTION AND OVERVIEW 1
- *Purpose* 1
- *Associated literature and similar initiatives* 2
- *Organization of SHACI* 5
- *SHACI unit overviews* 7
- *References* 16
- *Methodology* 18

2 - SHACI CRITERIA 21
- *SHACI as a guide to significant habitats* 21
- *Ecological attributes* 22
- *Cultural and recreational attributes* 25
- *Socio-economic considerations* 26

3 - HRM OVERVIEW – SHACI UNITS 4-6 27
- *References* 28

COASTAL ENVIRONMENTS 29

COASTAL ENVIRONMENT OVERVIEW 31
- *References* 31

4 - GEOLOGY 33
- *Subsurface geology and associated features* 33
- *Surficial geology and associated features* 34
- *Coastal geology* 37
- *References* 45

5 - CHEMICAL OCEANOGRAPHY 47
- *Nutrients* 47
- *Metals* 49
- *Synthetic organic chemicals and hydrocarbons* 51
- *Sources of contaminants* 52
- *Halifax Harbour, its approaches and tributaries* 55
- *St. Margarets Bay* 73
- *Eastern Shore* 73
- *Conclusion* 81
- *References* 81

6 - PHYSICAL OCEANOGRAPHY 91
- *Circulation* 91
- *Temperature and Salinity* 99
- *Sea Level* 104
- *Waves* 106
- *Wind* 107
- *References* 113

7 - COASTAL WETLANDS 117
- *Salt marshes* 127
- *Eelgrass* 130
- *Bogs and fens* 136
- *Coastal saline ponds* 137
- *Estuarine and marine flats* 141

Wetland systems *143*
References *148*

COASTAL LIFE **157**

8 - PLANKTON 159
Phytoplankton *159*
Zooplankton *166*
Coastal plankton issues *171*
Local threats to plankton *173*
References *173*
9 - MARINE PLANTS 179
Distribution and habitat *179*
Population status and growth *182*
Harvest *182*
Significant areas *183*
Threats and vulnerability *184*
Knowledge gaps *184*
References *185*
10 - MARINE INVERTEBRATES 189
Littoral fauna *189*
Subtidal fauna *189*
Commercial species *201*
Non-commercial species *218*
Threats to invertebrates *221*
References *223*
11 - FISH 231
Marine fish *231*
Diadromous species *257*
References *266*
12 - MARINE ASSOCIATED BIRDS 275
Seabirds *275*
Shorebirds and marsh birds of coastal wetlands *295*
Waterfowl *299*
Raptors *301*
Significant bird areas *303*
Threats to marine birds *304*
References *306*
13 - MARINE REPTILES 311
Leatherback turtle *311*
Loggerhead turtle *311*
Threats to marine turtles *312*
References *314*
14 - MARINE MAMMALS 319
Cetaceans: Whales, dolphins and porpoises *319*
Whale watching *320*
Seals (pinnipeds) *321*
Threats to marine mammals *322*
References *324*
15 - SPECIES AT RISK 327
Endangered species *328*
Threatened species *331*
Species of special concern *332*
Extinct *336*
Extirpated *336*
References *337*
16 - MARINE BIOINVADERS 343

Marine plants ... 345
Marine invertebrates ... 346
Urochordates ... 347
Fish ... 347
Bryozoans ... 347
References ... 348

COASTAL INDUSTRIES ... **353**

17 - FISHERY ... 355
Invertebrates ... 357
Fish ... 369
References ... 393
18 - AQUACULTURE ... 399
Species summaries ... 399
Aquaculture locations ... 409
Opportunities ... 411
Threats of aquaculture operations ... 412
Threats to aquaculture operations ... 412
References ... 412
19 - MARINE TRANSPORTATION ... 415
References ... 416
20 - TOURISM AND RECREATION ... 419
National historic sites ... 421
Provincial, community and heritage parks ... 422
Beaches ... 423
Boat tours and charters ... 423
Coastal walking/hiking trails ... 427
Bouldering ... 428
Cruise ships ... 429
References ... 429

RESTRICTED USE AREAS ... **433**

21 - RESTRICTED LAND USE - EXISTING LAND USE DESIGNATIONS ... 435
Types of restricted land use areas ... 435
References ... 463
22 - RESTRICTED WATER USE ... 469
Shellfish closure areas ... 469
Fisheries closures ... 471

SIGNIFICANT HABITATS ... **481**

23 - SIGNIFICANT HABITATS ... 483
Areas identified as significant habitats ... 492
References ... 497

List of figures

Figure 1-1 Natural History of Nova Scotia Theme Region 800 Atlantic Coast 3

Figure 1-2 Natural History of Nova Scotia Theme Region 900 Offshore and Continental Shelf 3

Figure 1-3 SHACI Units 5

Figure 1-4 SHACI Units 1, 2 and 3 7

Figure 1-5 SHACI Units 4, 5 and 6 9

Figure 1-6 SHACI Units 7, 8 and 9 11

Figure 1-7 SHACI Units 10 and 12 13

Figure 1-8 SHACI Unit 11 14

Figure 3-1 Regional context of SHACI Units 4-6 study area 27

Figure 4-1 Surficial geology of SHACI Units 4-6 36

Figure 4-2 LiDAR image of Story Head, Chezzetcook Inlet 41

Figure 4-3 Chezzetcook Inlet at (a) mean tide and (b) high tide, with indexed colour bar for decimetres 41

Figure 4-4 Annual mean sea levels at Halifax tide gauge 1895-1998 42

Figure 5-1 Sediment concentrations of lead in Halifax Harbour with respect to MEQ thresholds 59

Figure 5-2 Sediment concentrations of copper in Halifax Harbour with respect to MEQ thresholds 60

Figure 5-3 Sediment concentrations of mercury in Halifax Harbour with respect to MEQ thresholds 61

Figure 5-4 Sediment concentrations of zinc in Halifax Harbour with respect to MEQ thresholds 62

Figure 5-5 Sediment concentrations of cadmium in Halifax Harbour with respect to MEQ thresholds 63

Figure 5-6 Sediment concentrations of chromium in Halifax Harbour with respect to MEQ threshold 64

Figure 5-7 Sediment concentrations of PCBs in Halifax Harbour with respect to MEQ thresholds 66

Figure 5-8 Sediment concentrations of PAHs in Halifax Harbour with respect to MEQ thresholds 68

Figure 5-9 Sediment concentrations of lead in Petpeswick Inlet and Ship Harbour with respect to MEQ thresholds 75

Figure 5-10 Sediment concentrations of copper in Petpeswick Inlet and Ship Harbour with respect to MEQ thresholds 76

Figure 5-11 Sediment concentrations of mercury in Petpeswick Inlet and Ship Harbour with respect to MEQ thresholds 77

Figure 5-12 Sediment concentrations of chromium in Petpeswick Inlet and Ship Harbour with respect to MEQ thresholds 78

Figure 5-13 Sediment concentrations of cadmium in Petpeswick Inlet and Ship Harbour with respect to MEQ thresholds 79

Figure 6-1 Schematic of the general circulation on the Scotian Shelf 92

Figure 6-2a Seasonal along-shelf baroclinic currents on Halifax Section for winter, spring, summer and fall 92

Figure 6-2b Monthly transports to the southwest of Nova Scotia Current 0-100 m for the inner shelf 92

Figure 6-3 Mean currents for the inner shelf in winter (JFM), spring (AMJ), summer (JAS) and fall (OND) 93

Figure 6-4 Seasonal mean currents (0-5 m) from a numerical model of the Scotian Shelf circulation 94

Figure 6-5 The M2, K1 and O1 tidal ellipses for SHACI Units 4-6 95

Figure 6-6 Seasonal mean currents for St. Margarets Bay for winter (JFM), spring (AMJ), summer (JAS) and fall (OND) 96

Figure 6-7a Seasonal mean currents for Halifax Harbour 97

Figure 6-7b Annual mean currents from the Narrows in Halifax Harbour 98

Figure 6-7c Average currents from the outer section of Halifax Harbour 98

Figure 6-8 Seasonal mean currents for Ship Harbour 99

Figure 6-9 Vertical structure of long-term monthly averaged temperature, Salinity and sigma-t (density) for the shelf region of Units 4-6 100

Figure 6-10 Average, standard deviations, maxima and minima of temperature, salinity and sigma-t 101

Figure 6-11 Sea surface temperature, July 25, 1984 102

Figure 6-12a Average, standard deviations, maxima and minima of temperature 103

Figure 6-12b Annual sea surface temperature anomalies for Halifax Harbour 1926-2004 103

Figure 6-13 Monthly, annual and linear trend of sea level at Halifax 105

Figure 6-14 Distribution of hourly sea levels at Halifax about the long-term mean and trend 105

Figure 6-15 Cumulative distribution of Halifax sea level about the long-term mean and trend 105

Figure 6-16 Monthly significant wave height statistics for the shelf region of SHACI Units 4-6 106

Figure 6-17 Annual significant wave height-peak period percentage occurrence distribution for the shelf region of SHACI Units 106

Figure 6-18 Annual significant wave height direction percentage occurrence distribution for the shelf region of SHACI units 4-6 106

Figure 6-19 Distribution of hourly wind speeds at Shearwater 1971-2000 108

Figure 6-20 Distribution of hourly wind speeds at Sable Island 1971-2000 110

Figure 6-21 Monthly average hourly wind speeds from Shearwater and Sable Island 112

Figure 6-22 Time series of shelf ice cover for SHACI Units 4-6 112

Figure 7-1 Cole Harbour area (Unit 5) 119

Figure 7-2 West Marsh and Lawrencetown area (Unit 5) 120

Figure 7-3 Three Fathom Harbour area (Unit 5)........ 121

Figure 7-4 Chezzetcook Inlet area (Unit 5) 122

Figure 7-5a Petpeswick Inlet and Musquodoboit Harbour area (Unit 5) 123

Figure 7-5b Petpeswick Inlet and Musquodoboit Harbour area (Unit 5) 124

Figure 7-6 Jeddore Harbour area (Unit 5)........ 125

Figure 7-7 Clam Harbour area (Unit 5) 126

Figure 7-8 Vegetation zones in a typical salt marsh system 127

Figure 7-9 Cole Harbour wetlands (Unit 5) 146

Figure 8-1a Phytoplankton cell densities at 5 m depth in Bedford Basin, (1993-2000) 161

Figure 8-1b Synechococcus cell densities at 5 m depth in Bedford Basin, (1993-2000)........ 161

Figure 8-2 Chlorophyl concentration (mg/M^3) measured at 1, 5, 10 and 60 m depth in Bedford Basin, 1992-2002 161

Figure 8-3 Bacteria cell density (cells/m/L) at 1, 5 and 10 depths in Bedford Basin, 1992-2003 162

Figure 8-4 Chlorophyll a concentration at Halifax Line Station 2, October 24, 2001........ 162

Figure 8-5 Chlorophyll a concentration (ug/L) at Halifax Line Station 2, 2001 163

Figure 8-6 Phytoplankton total abundance, relative abundance by major groups and ratio between diatoms and dinoflagellates at Halifax Line Station 2, 2000 164

Figure 8-7 Total wet weight of zooplankton in Bedford Basin 167

Figure 8-8 Total zooplankton abundance and relative abundance of major plankton groups at Station 2 of the AZMP 168

Figure 8-9 Total copepod abundance and relative abundance of major copepod species at Station 2 of the AZMP in 2002 169

Figure 10-1a Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 4a 203

Figure 10-1b Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 4b............................. 204

Figure 10-1c Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 5a 205

Figure 10-1d Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 5b............................. 206

Figure 10-1e Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 5c............................. 207

Figure 10-1f Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 6a 208

Figure 10-1g Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 6b............................. 209

Figure 10-1h Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 6c............................. 210

Figure 11-1 SHACI Units 4, 5 and 6, NAFO Units 4Xm and 4Wk boundaries, and Halifax County lines.. 232

Figure 11-2 Cod spawning areas in SHACI Units 4, 5 and 6 236

Figure 11-3 Cod juvenile areas in SHACI Unit 6 238

Figure 11-4 Pollock spawning areas in SHACI Units 4, 5 and 6 239

Figure 11-5 Pollock juvenile areas in SHACI Unit 4 241

Figure 11-6 Haddock spawning areas in SHACI Units 4, 5 and 6 242

Figure 11-7 Haddock juvenile areas in SHACI Units 4, 5 and 6 245

Figure 11-8 Redfish Management Unit 3 246

Figure 11-9 Hake spawning areas in SHACI Units 5 and 6 248

Figure 11-10 Hake juvenile areas in SHACI Units 4, 5 and 6 249

Figure 11-11 Herring spawning areas in SHACI Units 4 and 5 253

Figure 11-12 Swordfish landings in SHACI Units 4-6 256

Figure 11-13 Bluefin tuna landings in SHACI Units 4-6 256

Figure 11-14 Salmon rivers in SHACI Units 4, 5 and 6 258

Figure 11-15 Salmon fishing areas (SFAs) 20 and 21 261

Figure 12-1a Locations of seabird colonies and seal haulouts in SHACI Unit 4a 278

Figure 12-1b Locations of seabird colonies and seal haulouts in SHACI Unit 4b 280

Figure 12-1c Locations of seabird colonies and seal haulouts in SHACI Unit 5a 282

Figure 12-1d Locations of seabird colonies and seal haulouts in SHACI Unit 4b 284

Figure 12-1e Locations of seabird colonies and seal haulouts in SHACI Unit 5c 286

Figure 12-1f Locations of seabird colonies and seal haulouts in SHACI Unit 6a 288

Figure 12-1g Locations of seabird colonies and seal haulouts in SHACI Unit 6b 291

Figure 12-1h Locations of seabird colonies and seal haulouts in SHACI Unit 6c 293

Figure 17-1 SHACI Units 4, 5 and 6, NAFO Units 4Xm and 4Wk boundaries, and Halifax County lines 356

Figure 17-2 Lobster fishing areas (LFAs) 31B, 32, 33 359

Figure 17-3 Fisheries Statistical Districts 361

Figure 17-4 Snow crab fishing areas (CFAs) 24E, 24C and NAFO division 4X 365

Figure 17-5 Snow crab landings in SHACI Units 4-6 (1995-2002) 367

Figure 17-6 Rock crab landings in SHACI Units 4-6 (1995-2002) 368

Figure 17-7 Cod landings in SHACI Units 4-6 (1995-2002) 373

Figure 17-8 Pollock landings in SHACI Units 4-6 (1995-2002) 374

Figure 17-9 Silver hake landings in SHACI Units 4-6 (1995-2002) 376

Figure 17-10 White hake landings in SHACI Units 4-6 (1995-2002) 377

Figure 17-11 Redfish Management Unit 3 378

Figure 17-12 Redfish landings in SHACI Units 4-6 (1995-2002) 379

Figure 17-13 Haddock landings in SHACI Units 4-6 (1995-2002) 380

Figure 17-14 Herring landings in SHACI Units 4-6 (1995-2002) 384

Figure 17-15 Mackerel landings in SHACI Units 4-6 (1995-2002) 385

Figure 17-16 Bluefin tuna landings in SHACI Units 4-6 (1995-2002) 386

Figure 17-17 Swordfish landings in SHACI Units 4-6 (1995-2002) 387

Figure 17-18 Blue shark landings in SHACI Units 4-6 (1995-2002) 388

Figure 17-19 Porbeagle shark landings in SHACI Units 4-6 (1995-2002) 389

Figure 17-20 Salmon fishing areas (SFAs) 20 and 21 391

Figure 18-1 Atlantic salmon, steelhead salmon, Atlantic cod and Atlantic halibut lease sites in western St. Margarets Bay 400

Figure 18-2 Atlantic salmon, steelhead salmon, blue mussel, sea scallop and European oyster aquaculture site leases in Ship Harbour 401

Figure 18-3 Steelhead salmon aquaculture site in Quoddy Harbour 402

Figure 18-4 Blue mussel, sea scallops and European aquaculture sites and speckled trout U-Fish in Eastern St. Margarets Bay 404

Figure 18-5 Blue mussel, sea scallops and European aquaculture sites and speckled trout U-Fish in Blind Bay and Prospect Bay 405

Figure 18-6 Blue mussel aquaculture sites in Pond and Jeddore Harbour 406

Figure 18-7 Blue mussel aquaculture site in Popes Harbour 406

Figure 18-8 Blue mussel and sea scallops aquaculture sites in Marie Joseph Harbour 407

Figure 19-1 Standard shipping routes along the Atlantic coast of Nova Scotia 416

Figure 21-1a Restricted and limited land use areas in SHACI Unit 4a 436

Figure 21-1b Restricted and limited land use areas in SHACI Unit 4b 437

Figure 21-1c Restricted and limited land use areas in SHACI Units 4b/5a 438

Figure 21-1d Restricted and limited land use areas in SHACI Unit 5b 439

Figure 21-1e Restricted and limited land use areas in SHACI Unit 5c 440

Figure 21-1f Restricted and limited land use areas in SHACI Unit 6a 441

Figure 21-1g Restricted and limited land use areas in SHACI Unit 6b/6c 442

Figure 22-1 Salmon Fishing Areas (SFAs) 19 to 23 are closed to commercial salmon fishing by any gear other than angling 474

Figure 22-2 Herring Fishing Area 20 closures to mobile gear fishing for herring 475

Figure 22-3 Clam harvesting area closure in East Chezzetcook 476

Figure 22-4 Clam Harvesting Area 4 closure of tidal waters to clam harvesting from January 1 to March 31 477

Figure 22-5 NAFO Divisions 4VWX and 5 are closed to fishing by means of Class C1-C3000 for halibut and Class C1017 for groundfish until March 31, 2005-03-31 478

Figure 22-6 Lobster Fishing Area (LFA) 33 is closed to lobster fishing from June 1 to November 30 479

Acknowledgements

Many people contributed to this report by providing information and reviewing portions of the document. We would like to thank the following people who reviewed sections of this document: Andrew Bagnell, Nova Scotia Department of Agriculture and Fisheries; Toby Balch, Nova Scotia Department of Agriculture and Fisheries; Cyril Boudreau, Nova Scotia Department of Agriculture and Fisheries; Don Bowen, Fisheries and Oceans Canada; Andrew Boyne, Environment Canada; Maria-Ines Buzeta, Fisheries and Oceans Canada; Lise Chapman, Dalhousie University; John Charles, Halifax Regional Municipality; Lew Clancy, Nova Scotia Department of Agriculture and Fisheries; Don Clark, Fisheries and Oceans Canada; Kirsten Clark, Fisheries and Oceans Canada; Christopher Craig, Environment Canada; Gordon Fader, Natural Resources Canada; Glen Harrison, Fisheries and Oceans Canada; Erica Head, Fisheries and Oceans Canada; Glen Herbert, Fisheries and Oceans Canada; Peter Hurley, Fisheries and Oceans Canada; Mike James, Dalhousie University; Bill Li, Fisheries and Oceans Canada; Geordie MacLachlan, Nova Scotia Department of Agriculture and Fisheries; Arran McPherson, Fisheries and Oceans Canada; David Millar, Fisheries and Oceans Canada; Bob Miller, Natural Resources Canada; Randy Milton, Nova Scotia Department of Natural Resources; John Neilson, Fisheries and Oceans Canada; Robert Ogilvie, Nova Scotia Museum; Shane O'Neil, Fisheries and Oceans Canada; Brian Petrie, Fisheries and Oceans Canada; Michael Power, Fisheries and Oceans Canada; Glyn Sharp, Fisheries and Oceans Canada; Ron Smith, Fisheries and Oceans Canada; John Tremblay, Fisheries and Oceans Canada; Sabina Wilhelm, Environment Canada; and Phil Yeats, Fisheries and Oceans Canada.

The following people provided data and/or information and are thanked: Toby Balch, Nova Scotia Department of Agriculture and Fisheries; Michel Biron, Fisheries and Oceans Canada; Don Bowen, Fisheries and Oceans Canada; Tony Bowron, Ecology Action Centre; Andrew Boyne, Environment Canada; Mark Butler, Ecology Action Centre; Lise Chapman, Dalhousie University; Tony Chapman, Dalhousie University; Lewis Clancy, Nova Scotia Department of Agriculture and Fisheries; Peter Comeau, Fisheries and Oceans Canada; Jerry Conway, Fisheries and Oceans Canada; Christopher Craig, Environment Canada; Derek Davis; Gordon Fader, Natural Resources Canada; Paul Fanning, Fisheries and Oceans Canada; Robert Fournier, Dalhousie University; Keith Freeman, Fisheries and Oceans Canada; Shannon Gowans, Blind Bay Cetacean Studies; Glen Harrison, Fisheries and Oceans Canada; Bruce Hatcher, Dalhousie University; Andrew Hebda, Museum of Natural History; Peter Hurley, Fisheries and Oceans Canada; Justin Huston, Nova Scotia Department of Agriculture and Fisheries; Mike James, Dalhousie University; Peter Koeller, Fisheries and Oceans Canada; Bill Li, Fisheries and Oceans Canada; Brian Kinsman, Nova Scotia Department of Natural Resources; David MacKinnon, Nova Scotia Department of Environment and Labour; Geordie MacLachlan, Nova Scotia Department of Agriculture and Fisheries; Eliza Manuel, Peggy's Cove Preservation Society; Gavin Manson, Natural Resources Canada; Larry Marshall, Fisheries and Oceans Canada; Robert Miller, Fisheries and Oceans Canada; Randy Milton, Nova Scotia Department of Natural Resources; Peter Newbould, Nova Scotia Department of Service and Municipal Relations; Shane O'Neil, Fisheries and Oceans Canada; Brian Petrie, Fisheries and Oceans Canada; Doug Pezzack, Fisheries and Oceans Canada; Bob Pietrzak, Fisheries and Oceans Canada; Dale Roddick, Fisheries and Oceans Canada; Cheryl Ryder, National Marine Fisheries Service; Robert Scheibling, Dalhousie University; Glyn Sharp, Fisheries and Oceans Canada; Sean Smith,

Fisheries and Oceans Canada; Wayne Stobo, Fisheries and Oceans Canada; John Tremblay, Fisheries and Oceans Canada; Gary Weber, Fisheries and Oceans Canada; Hal Whitehead, Dalhousie University; and Phil Yeats, Fisheries and Oceans Canada.

Abstract

McCullough, D.M., P.A. Doherty, H.L. Schaefer, C. Deacoff, S.K. Johnston, D.R. Duggan, B.D. Petrie and V.V. Soukhovtsev. 2005. Significant Habitats: Atlantic Coast Initiative (SHACI). Halifax Regional Municipality - Units 4-6. Can. Manuscr. Rep. Fish. Aquat. Sci. 2724: xvii + 501 pp.

Coastal areas including estuaries, bays and continental shelves constitute roughly 7.4 % of the sea's area (Sharp 1988). They are among the most diverse yet heavily altered marine ecosystems and thus warrant special consideration and protection. In this light, Significant Habitats Atlantic Coast Initiative (SHACI) is a project aimed at identifying, mapping, and documenting significant coastal habitats along the Atlantic Coast of Nova Scotia. These coastal areas extend from Yarmouth on the southwest shore to Cape North on the northern coast of Cape Breton Island, including the Bras d'Or Lakes and from the coastal areas onshore to the 12 nautical mile offshore limit of Canada's Territorial Sea. The Oceans and Coastal Management Division, Maritimes Region, Fisheries and Oceans Canada is undertaking this initiative primarily to contribute to programs and initiatives being developed under the *Oceans Act* for the nearshore Atlantic coast region.

The purpose of this document is to summarize what is known about the coastal life and environments within SHACI Units 4, 5 and 6. These Units include coastal waters extending from Blandford, Lunenburg County to Liscomb, Guysborough County. SHACI Units 4-6 are characterized by a rocky coast with a complex shoreline of inlets, islands, reefs and embayments. The complex nature of the shoreline allows for extensive salt marshes in the area, particularly in Unit 5. The rugged, exposed rocky shores provide excellent habitat for a variety of flora and fauna. Based on SHACI criteria, several significant habitats in SHACI Units 4-6 were identified, including Musquodoboit Harbour and St. Margarets Bay.

Résumé

McCullough, D.M., P.A. Doherty, P.A., H.L. Schaefer, C. Deacoff, S.K. Johnston, D.R. Duggan, B.D. Petrie et V.V. Soukhovtsev. 2005. *Significant* Habitats: Atlantic Coast Initiative (SHACI). Halifax Regional Municipality - Units 4-6. Rapport manuscrit canadien des sciences halieutiques et aquatiques. 2724 : xvii + 501 pp.

Les zones côtières, y compris les estuaires, les baies et les plateaux continentaux, constituent à peu près 7,4 % de la superficie des mers (Sharp, 1988). Étant donné qu'elles figurent parmi les écosystèmes marins les plus diversifiés, mais aussi les plus perturbés, elles doivent faire l'objet de considérations et de protections spéciales. À cette fin, l'Initiative concernant les habitats importants de la côte Atlantique (ICHICA) vise à déterminer, à cartographier et à documenter les habitats côtiers importants de la côte atlantique de la Nouvelle-Écosse. Les zones côtières ciblées par cette initiative s'étendent depuis Yarmouth, sur la côte sud-ouest, jusqu'à Cape North, sur la côte nord de l'île du Cap-Breton, y compris le lac Bras d'Or, et depuis la laisse de haute mer jusqu'à la limite des eaux territoriales canadiennes, à 12 milles nautiques vers le large. La Division de la gestion côtière et des océans, Région des Maritimes, de Pêches et Océans Canada a lancé cette initiative principalement dans le but de contribuer à la réalisation de programmes mis en oeuvre sur la côte atlantique du pays, conformément à la *Loi sur les océans*.

Le présent document résume les connaissances actuelles au sujet de la vie et des environnements côtiers des unités 4, 5 et 6 de l'ICHICA. Cette zone comprend les eaux côtières depuis Blandford, comté de Lunenburg jusqu'à Liscomb, comté de Guysborough. Les unités 4, 5 et 6 de l'ICHICA se caractérisent par une côte rocheuse, dont le rivage se compose de bras de mer, d'îles, de récifs et d'enfoncements. La complexité du rivage favorise la formation de vastes marais salés dans la région, en particulier dans la zone de l'unité 5. Le rivage rocheux accidenté et exposé offre un habitat propice à une faune et à une flore variées. En fonction des critères de l'ICHICA, plusieurs habitats importants ont été dénombrés dans la zone des unités 4, 5 et 6, y compris Musquodoboit Harbour et St. Margarets Bay.

1 – SHACI introduction and overview

Coastal areas, including estuaries, bays and continental shelves, constitute roughly 7.4% of the sea's area (Sharp 1988). They are among the most biologically diverse yet heavily altered marine ecosystems, and thus warrant special consideration and protection. In this light, Significant Habitats: Atlantic Coast Initiative (SHACI) is a project aimed at identifying, mapping and documenting significant coastal habitats along the Atlantic Coast of Nova Scotia. These coastal areas extend from Yarmouth on the southwest shore, to Cape North on the northern coast of Cape Breton Island, and include the Bras d'Or Lakes. The extents are from the high tide mark to the 12 nautical mile offshore limit of Canada's Territorial Sea. The Oceans and Coastal Management Division, Maritimes Region, Fisheries and Oceans Canada is undertaking this initiative primarily to contribute to programs and initiatives being developed under the *Oceans Act* for the nearshore Atlantic coast region.

Purpose

The *Oceans Act*, passed in 1997, mandates the development and implementation of a national strategy for oceans management, and commits the Government of Canada to a new management approach for the ocean based on the principles of sustainable development, integrated management and precautionary and ecosystem approaches. A guiding principle of this strategy is the integrated management of all activities in estuaries, coastal waters and marine waters that form part of Canada. The Department of Fisheries and Oceans' (DFO) approach to achieving this mandate is outlined in *Canada's Oceans Strategy* and the *Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada* released July 2002. DFO is the lead federal department for the conservation, management, and sustainable development of renewable marine resources. In this capacity, DFO oceans and coastal managers and planners require the identification of significant habitats. Along the Atlantic Coast, these habitats will be identified through this initiative.

Canada is also committed globally to conserving marine biodiversity. In 1994, the International Union for the Conservation of Nature (IUCN) recommended that countries bordering oceans create systems of marine protected areas through legislation. In 1992, the *Convention on Biological Diversity* was opened for signature, and by 2001 had been adopted by more than 180 countries. Canada, an early signatory and the sixth country to ratify the agreement, is now committed to:

- Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, *inter alia*, the measures set out in this Convention relevant to the Contracting Party concerned; and,

- Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies (Article 6, 1992).

Through these national and international commitments, Canada is responsible for managing its oceans and their resources in a sustainable manner. The most sensible, efficient and effective way to plan for sustainable ocean use requires the identification of significant habitats in view of key gaps in our knowledge. Although much literature exists about specific Atlantic coast marine species and habitats, there is no current and comprehensive mapping initiative and/or documents that have combined this information for the purpose of identifying significant marine habitats.

The maps and reports produced through SHACI are intended for use by a general audience including ocean planners, fisheries managers, non-government organizations (NGOs), consultants, industry, and the public for purposes such as public education, coastal planning and resource management, and environmental assessments. This initiative is relevant to several federal programs under the *Oceans Act,* and will serve as a knowledge base for the creation and development of new initiatives. Generally, SHACI will:

- Provide an overview of what is known about Atlantic coast habitats and help to identify information gaps
- Be a key information source for the Marine Protected Areas (MPA) program by identifying significant areas along the coast that may require a higher level of protection provided through MPAs
- Support DFO's work on the identification of appropriate standards and measures for marine environmental quality
- Assist in identifying appropriate indicators and reference points for monitoring ecosystem health

SHACI is intended to support and influence decision-making regarding the use of the Atlantic coast of Nova Scotia. It will not, however, look in-depth at human activities and socio-economic issues, nor will it identify or recommend specific management actions.

Associated literature and similar initiatives

Atlantic coast in the literature

In a report commissioned by Parks Canada, P. Lane and Associates Limited (1992) reviewed the oceanography, geology, biology and marine history of the Scotian Shelf Marine Region, and identified candidate Marine Natural Areas of Canadian Significance (NACS). This report dealt with both nearshore and offshore regions of the Scotian Shelf. The study area was divided into six sub-regions defined according to geological and oceanographic boundaries, with four sub-regions: the South Shore, the Eastern Shore, Canso to Cape Breton Shore and the Bras d'Or Lakes. Based on this report, a twelve-member study team chose three candidate NACS for further appraisals by the Canadian Parks Service: Cape Sable and Offshore Upwelling, Sable Island and the Gully, and Canso and Offshore Islands.

The Natural History of Nova Scotia Volume One: Topics and Habitats (Davis and Browne 1996a), and *Volume Two: Theme Regions* (Davis and Browne 1996b) contain much information for the Atlantic coast of Nova Scotia. The Davis and Browne approach to creating Theme Regions along the coast was to imagine a person standing in the intertidal zone. What this individual would observe when facing landward was included in the Region 800 Atlantic Coast (Figure 1-1), and what the individual would observe when facing seaward was considered Region 900 Offshore/Continental Shelf (Figure 1-2) (Davis pers. comm. 2001). Given the SHACI study area, both marine-based (Region 900) and land-based Regions (Region 800 and others) are relevant. The Theme Regions are then further subdivided hierarchically into Districts and Units.

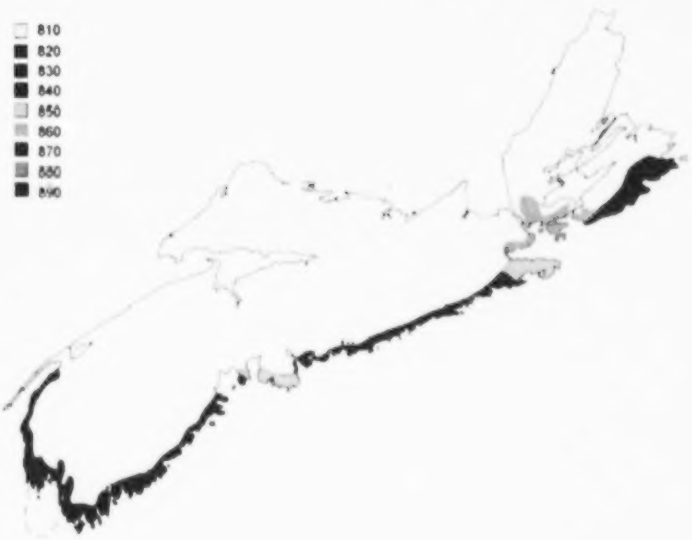


Figure 1-1: Natural History of Nova Scotia Theme Region 800 Atlantic Coast (Davis and Browne 1996b)

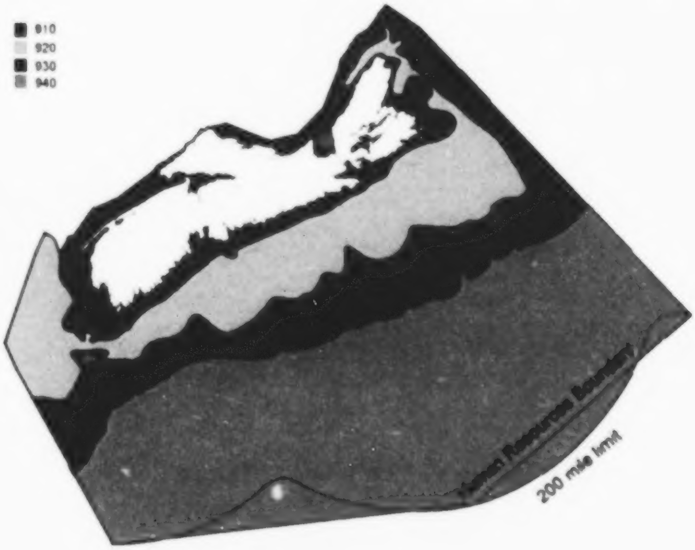
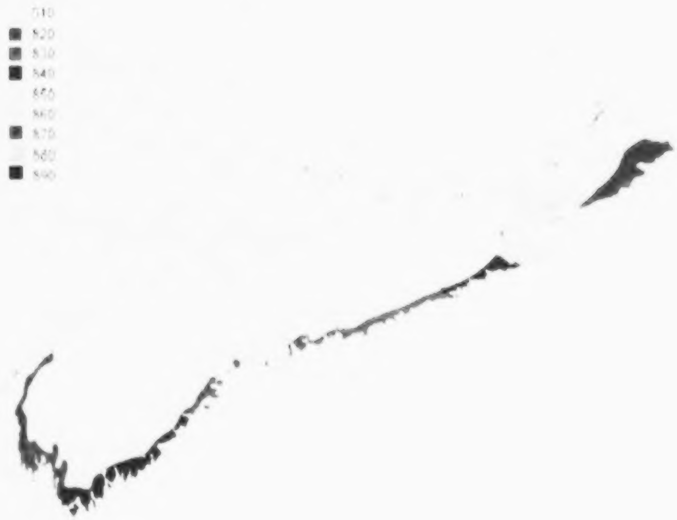


Figure 1-2: Natural History of Nova Scotia Theme Region 900 Offshore/Continental Shelf (Davis and Browne 1996b)

Other studies and reports have examined either a geographical component of a particular species group, or a habitat type found within the SHACI study area. In one of the few comprehensive reports on a particular area, Kenchington (1998) compiled all known information about the Bras d'Or Lakes and the surrounding landmass within their watershed as a basic reference source for integrated management of the Bras d'Or Lakes region.



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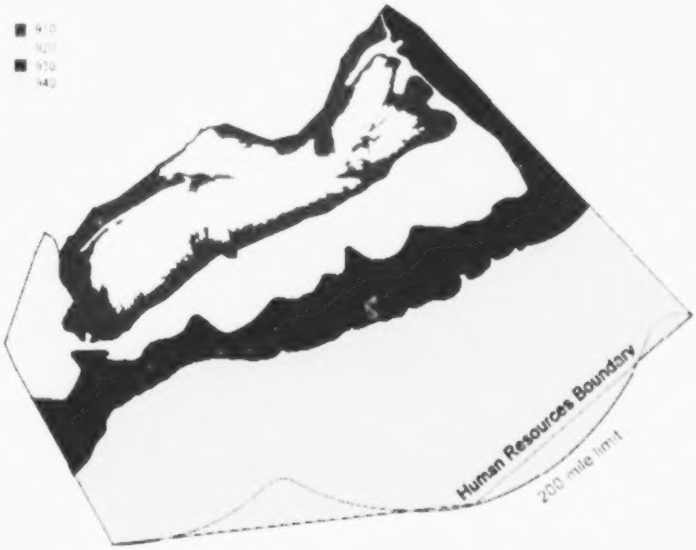

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A series of inventory-type reports entitled *Community Ecological Requirements and Guidelines for Marine Habitats* (Hawkins 1997) provides a detailed ecological overview of rocky intertidal, mudflat and salt marsh habitats along the Atlantic shore of Nova Scotia.

Lock et al. (1994) produced the *Gazetteer of Marine Birds in Atlantic Canada: An Atlas of sea bird vulnerability to oil pollution*. It provides information about sensitive sea bird areas in Nova Scotia.

Similar initiatives in other regions of the Maritimes

Several similar DFO initiatives are in progress in other regions of the Maritimes. The *Preliminary Index of Regionally Critical Habitats for Certain Marine Species of Importance in Prince Edward Island and the Northwest Region of Nova Scotia* (Therrien et al. 2001) and *Preliminary Index of Essential Habitats for Certain Marine Species of Importance in the Eastern Region of New Brunswick* (Therrien et al. 2000) are reports aimed at identifying Critical Habitats in these regions. Therrien et al. (2000, 2001) selected four themes to describe essential habitat: Ecological Features, Vulnerability (threats and human pressures), Socio-economic characteristics, and Support (favourable and unfavourable factors). Data collected for these reports was gathered in three stages: by consulting DFO and provincial government researchers, by a literature review, and by interviewing fisheries officers. These reports present information in the form of essential habitats for certain marine species. In this case, "essential habitat" refers to a "species habitat" (i.e. a vital habitat for a given species). The majority of areas identified were important for species of commercial or recreational interest; non-commercial species received less attention due in part to a lack of information. Many marine resources (e.g. kelp beds, small concentrations of pinniped or molluscs, etc.) and habitats (estuaries and lagoons) were not included due to their widespread distribution in their respective regions.

In the Bay of Fundy, the *Identification of Significant Marine and Coastal Areas* document was produced in 2003 with the aim to identify significant, community-valued or highly biodiverse marine areas in the Bay of Fundy, and make general recommendations (Buzeta et al. 2003). These areas were identified in the scientific literature, or suggested by academics, local experts, and a broad range of stakeholders through workshops and written submissions (Buzeta pers. comm. 2003).

An *Ecological Overview of the Scotian Shelf* was completed in 2002 (Breeze et al. 2002). This review provides a description of the major ecological components of the Scotian Shelf, summarizing what is known about its physical environment and marine life. The *Ecological Overview of the Scotian Shelf* will be closely linked with SHACI, as the two study areas abut and have linked oceanographic processes and common species and habitats.

Organization of SHACI

For organizational purposes, the SHACI study area is subdivided into twelve different units (Figure 1-3) based primarily on physical environmental factors. The SHACI units closely mirror many of the districts and units of the *Natural History of Nova Scotia* (Davis and Browne 1996b). The *Natural History of Nova Scotia* Districts were divided based upon major geomorphological characteristics, and further divided into Units based upon geomorphology, soil, and vegetation. The relationship between SHACI ecological units and those used in other systems used to subdivide the coast are indicated in Table 1-1.

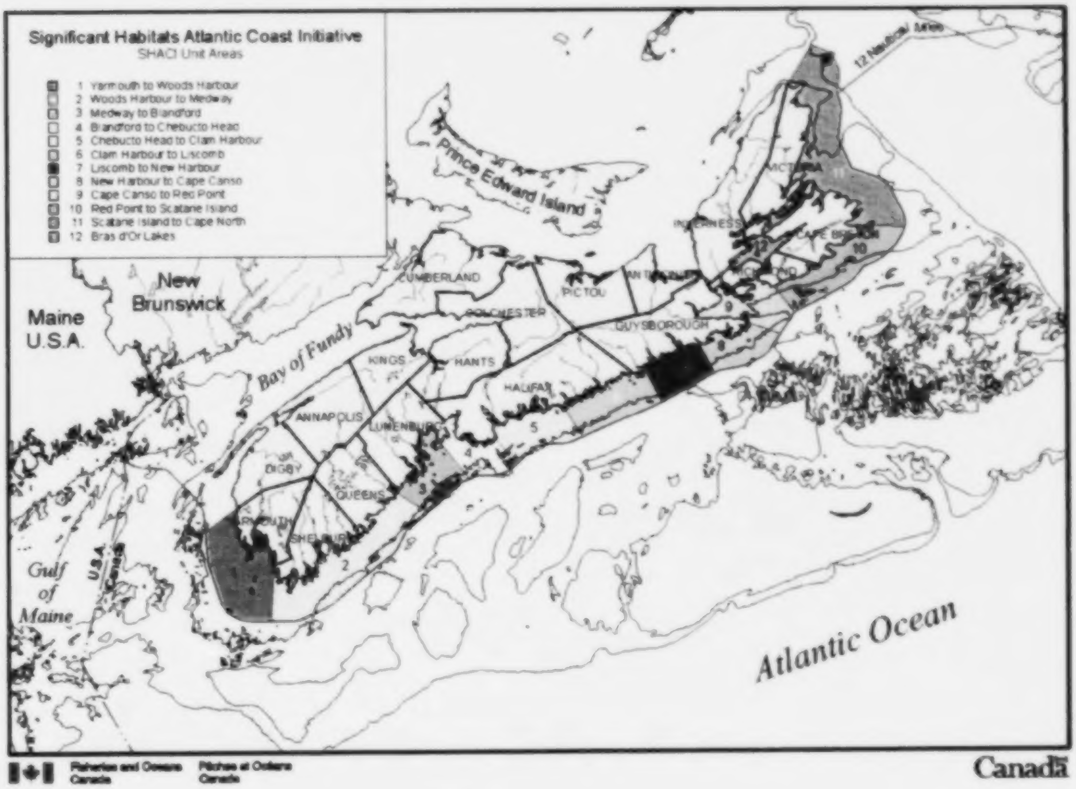
Significant Habitats Atlantic Coast Initiative
SHACI Unit Areas
1 Yarmouth to Woods Harbour
2 Woods Harbour to Medway
3 Medway to Blandford
4 Blandford to Chebucto Head
5 Chebucto Head to Clam Harbour
6 Clam Harbour to Liscomb
7 Liscomb to New Harbour
8 New Harbour to Cape Canso
9 Cape Canso to Red Point
10 Red Point to Scatarie Island
11 Scatarie Island to Cape North
12 Bras d'Or Lakes
12 Nautical Miles
Prince Edward Island
New Brunswick
Maine
U.S.A.
Bay of Fundy
CUMBERLAND
COLCHESTER
PICTOU
INVERNESS
GUYSBOROUGH
KINGS
HANTS
HALIFAX
ANNAPOLIS
LUNENBURG
DIGBY
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Figure 1-3: SHACI units

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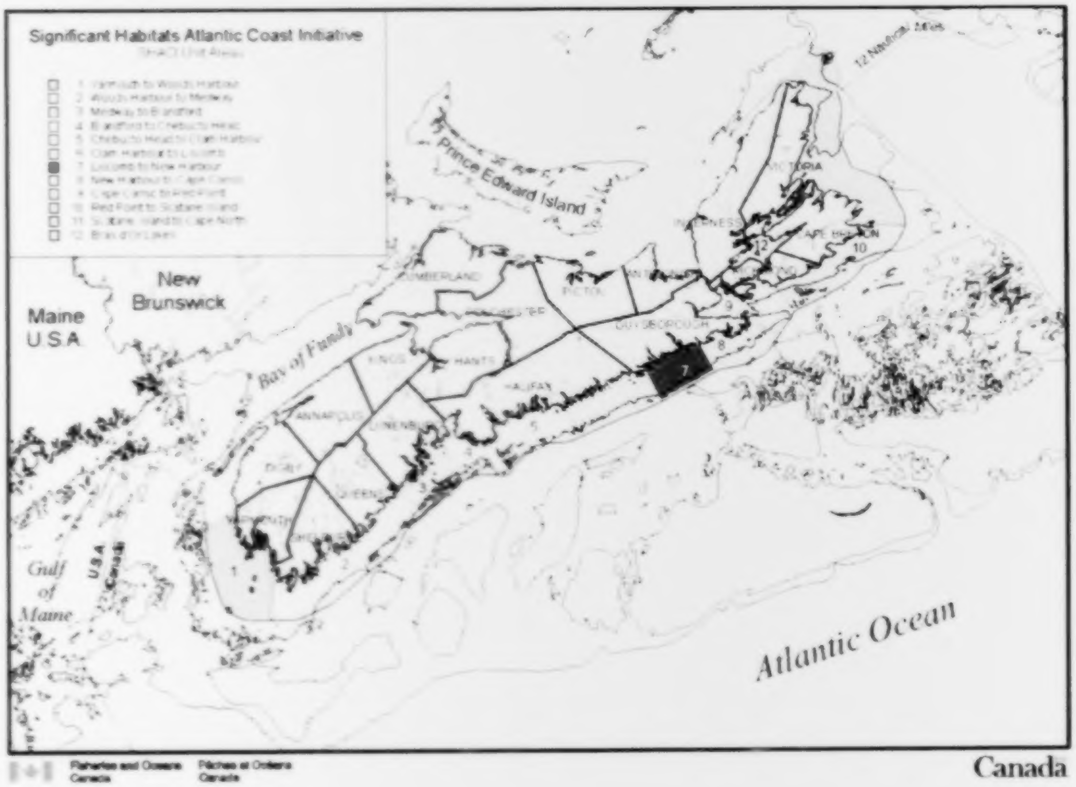
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Figure 1-3: SHACI units

District 910 Inner Shelf (Davis and Browne 1996b) includes the marine habitat from the intertidal seaward. District 910 includes: Unit 911 - Atlantic (SHACI Units 1- 10); Unit 915 - Sydney Bight (SHACI Unit 11); and Unit 916 - Bras d'Or Lakes (SHACI Unit 12).

Table 1-1: Relationship between SHACI units and those used in other studies

SHACI Unit.	NHNS MarineTheme Regions (Davis and Browne 1996b).	NHNS Coastal Theme Regions (Davis and Browne 1996b).	P. Lane and Associates (1992).
Unit 1 – Yarmouth to Woods Harbour	District 910 Inner Shelf Unit 911 Atlantic	District 830 Beaches and Islands • Unit 831 Tusket Islands	South Shore
Unit 2 – Woods Harbour to Medway	District 910 Inner Shelf Unit 911 Atlantic	District 840 Quartzite Headlands • Unit 841 Capes and Bays	South Shore
Unit 3 – Medway to Blandford	District 910 Inner Shelf Unit 911 Atlantic	District 830 Beaches and Islands • Unit 832 LaHave Drumlins	South Shore
Unit 4 – Blandford to Chebucto Head	District 910 Inner Shelf Unit 911 Atlantic	District 850 Granite Barrens • Unit 851 Pennant Barrens	South Shore
Unit 5 – Chebucto Head to Clam Harbour	District 910 Inner Shelf Unit 911 Atlantic	District 830 Beaches and Islands • Unit 833 Eastern Shore Beaches	Eastern Shore
Unit 6 – Clam Harbour to Liscomb	District 910 Inner Shelf Unit 911 Atlantic	District 830 Beaches and Islands • Unit 834 Bay of Islands,	Eastern Shore
Unit 7 - Liscomb to New Harbour	District 910 Inner Shelf Unit 911 Atlantic	District 840 Quartzite Headlands Unit 842 Guysborough Harbours	Eastern Shore
Unit 8 – New Harbour to Cape Canso	District 910 Inner Shelf Unit 911 Atlantic	District 850 Granite Barrens • Unit 852 Canso Barrens	Eastern Shore
Unit 9 –Cape Canso to Red Point (Chedabucto Bay)	District 910 Inner Shelf Unit 911 Atlantic	District 860 Sedimentary Lowlands	Canso to Cape Breton Shore
Unit 10 – Red Point to Scatarie Island	District 910 Inner Shelf Unit 911 Atlantic	District 870 Till Plain	Canso to Cape Breton Shore
Unit 11 – Scatarie Island to Cape North (Sydney Bight)	District 910 Inner Shelf Unit 915 Sydney Bight	District 530 Stony and Wet Plain • Unit 531 Sydney Coalfield District 550 Coastal Fringe • Unit 552 Victoria Coastal Plain	Canso to Cape Breton Shore
Unit 12 – Bras d'Or Lakes	District 910 Inner Shelf Unit 916 Bras d'Or Lake	District 560 Submerged Lowland	Bras d'Or Lakes

SHACI unit overviews

It is useful to gain a general understanding of the study area's ecological features and processes before assigning Significant Habitat status to any given area. Such an examination indicates the important differences between the ecological units found in the marine areas along our coast. As indicated in Table 1-1, many of the *Natural History of Nova Scotia* Theme Regions correspond with the SHACI study area. In their overview of these areas, Davis and Browne (1996b) provide information about marine ecological features which was used as a key reference for the following unit descriptions.

Unit 1 – Yarmouth to Woods Harbour

Unit 1 (Figure 1-4) has a submerged coastline with long promontories and inlets. Extensive areas of salt marsh, the dominant feature here, are present due to the ample sediment supply from glacial deposits. Unit 1 has relatively ice-free winter conditions and therefore provides important overwintering habitat for waterfowl. Coastal waters are nutrient rich and support a diverse marine fauna due to upwelling and tidal mixing (Davis and Browne 1996b).

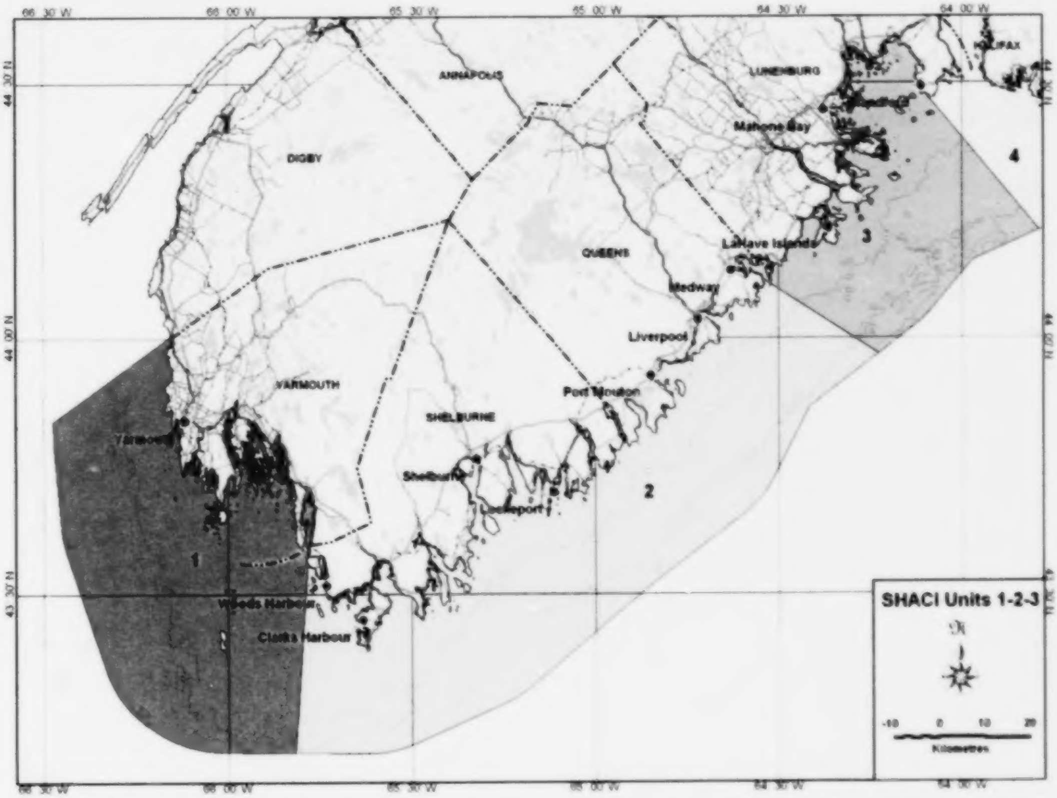

Figure 1-4: SHACI Units 1, 2 and 3

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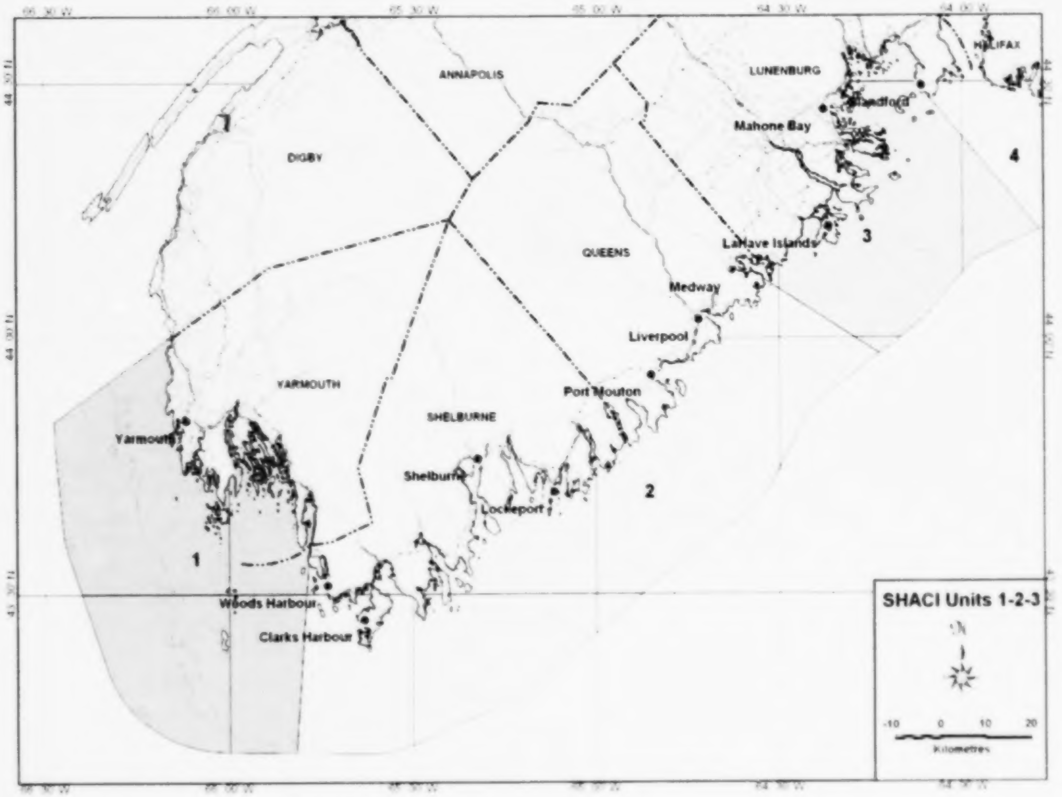

Figure 1-4: SHACI Units 1, 2 and 3

The productive lobster fishery here provides an economic base for this coastal area. Herring, mackerel, crab, scallop, and clams are also important fisheries; however, groundfishing has been reduced substantially in recent years. Rockweed, kelp, and to a lesser degree, Irish moss are commercially harvested. There are aquaculture sites within Unit 1 in the Tusket River Islands area, Lobster Bay and Pubnico Harbour (NSDAF 2005). Sand and gravel were commercially exploited here in the past.

Unit 2 – Woods Harbour to Medway

The coastal terrain in Unit 2 (Figure 1-4) consists of hummocky granite and greywacke bedrock with variable, but usually thin, till cover. The indented coastline is divided into well-developed capes and long narrow bays. Many chain lakes and rivers drain into the Atlantic via many inlets and estuaries in this area, and sand is generally abundant in Unit 2. A diversity of coastal habitats are found here including sand beaches, salt marshes, intertidal muds and sand at the heads of the longer inlets, tidal marshes, barachois ponds and cobble beaches (Davis and Browne 1996b). The sheltered inlets and mild, relatively ice-free winters provide wintering habitat for waterfowl.

Areas within Unit 2 are known for specific ecological features or habitats. Rocky shores are found primarily between Liverpool and Port Medway. Clarks Harbour and Cape Sable are important staging areas for shorebirds, as is Barrington Bay with its extensive mud flats. An important waterfowl wintering area is found between Lockeport and Port Mouton. Further offshore, overwintering pelagic seabirds and whales find nutrient rich waters. Warm water incursions from the Gulf Stream often introduce exotic tropical species to Unit 2 during the summer (Davis and Browne 1996b).

Unit 2 has a history of fishing, shipbuilding and forestry exports. Today, there is still a shipyard and major pulp and paper plant near Liverpool. The major local fishery is lobster. Herring, mackerel, sea urchins, groundfish, and some inshore crab are also fished. Offshore fishing vessels sail from many of the ports along this shore. Aquaculture takes place in numerous bays and inlets throughout this unit including Upper Woods Harbour, Shag Harbour, Barrington Passage, Port LaTour, Negro Harbour, Shelburne Harbour, Jordan Bay, Port L'Hebert (NSDAF 2005).

Unit 3 – Medway to Blandford

Unit 3 (Figure 1-4) has an ample sediment supply given the many drumlins found both in shoals and on islands offshore. In the southern area of this unit, there are slate bedrock promontories. There is a diversity of coastal habitats here including extensive sand beaches, cobble and shale beaches, rocky shores, tidal flats and salt marshes. Most of the wetlands are tidal, and salt marshes and eelgrass beds are common. The Lahave estuary is very wide where it crosses into this coastal area. Such rivers draining into this unit provide distinct estuarine conditions for brackish water species. The system of sheltered inlets and rocky shore also provides habitat for southern and northern faunal species respectively. Occasional summer incursions of slope waters introduce exotic tropical species to this unit. There are many locally important habitat areas for shorebirds and waterfowl (Davis and Browne 1996b).

Fishing dominates this coast, and access to offshore banks has resulted in a prosperous fishing industry. Lobster is the major coastal fishery; however, herring, mackerel and sea urchins are also harvested. Numerous aquaculture operations exist in this Unit in the LaHave, Moshers Bay, Rose Bay, Lunenburg Bay and Mahone Bay (NSDAF 2005), as well as a developing shrimp industry. The LaHave Islands and Mahone Bay area are important tourist and recreational destinations. Shell middens from traditional Mi'kmaq camps have been found in the St. Margarets Bay area indicating traditional use of this area.

Unit 4 – Blandford to Chebucto Head

Unit 4 (Figure 1-5) is part of Halifax Regional Mnicipality (HRM). It differs from its surrounding units because it is a large granite promontory. The shoreline is rocky with low cliffs that have, in some places, been swept clear of all sediment and are bordered by boulder and cobble shore, or sandy beaches. There is little suitable shorebird or waterfowl habitat in Unit 4. Breeding birds include gulls, cormorants, Osprey, and Great Blue Heron. There are a few Bald Eagle breeding sites and Double-crested Cormorant colonies. Particularly in the late summer, slope water influence provides productive plankton areas and the presence of whales (Davis and Browne 1996b).

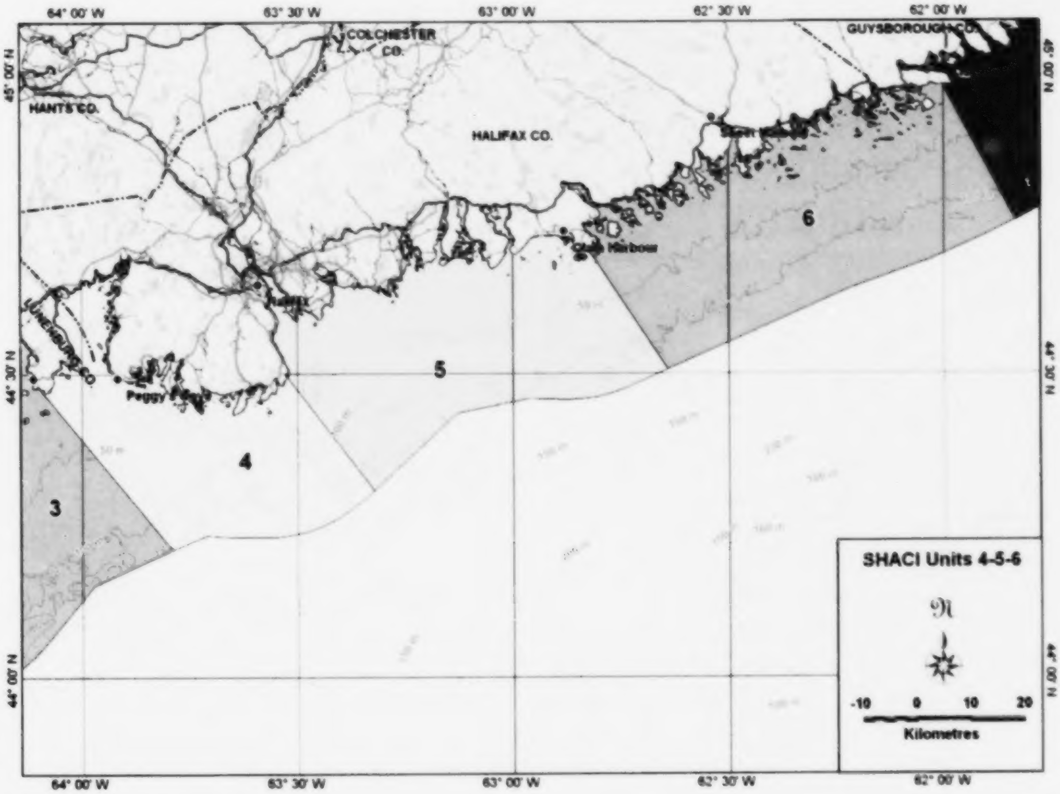

Figure 1-5: SHACI Units 4, 5 and 6

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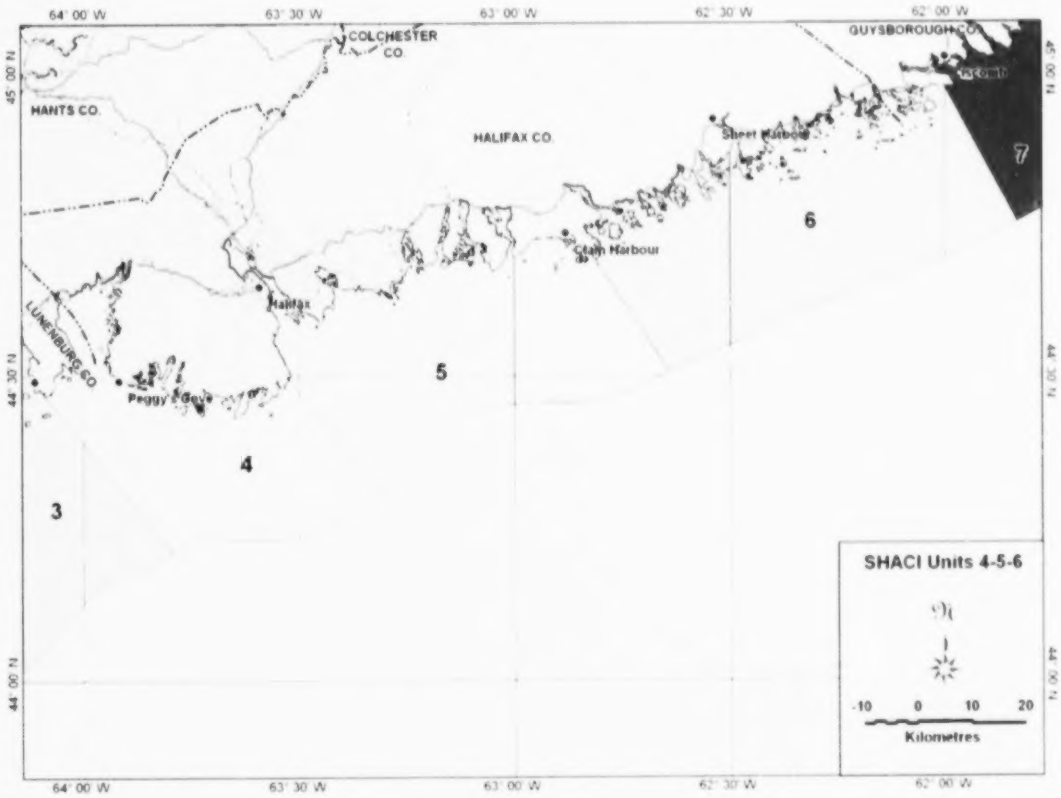

Figure 1-5: SHACI Units 4, 5 and 6

Small fishing operations for lobster and other species exist in this area. Peggy's Cove, a major tourist destination, is located within Unit 4. There are aquaculture sites in Unit 4 in St. Margarets Bay, Blind Bay and Prospect Bay (NSDAF 2005). This area is widely used for recreational boating, hiking, water sports, beaches and ecotourism operations such as whale and bird watching. As well, many commuters who work in the region's major city, Halifax, live in this area.

Unit 5 – Chebucto Head to Clam Harbour

Unit 5 (Figure 1-5) is a part of HRM. It is an indented, drowned coastline with headlands, long inlets and drumlin islands. Spits and barrier beaches connect the promontories and islands, thus protecting the large, shallow estuaries from ocean waves and allowing the development of salt marshes. Rocky shore, sand beach, salt marsh, and barachois pond habitats are found in Unit 5. Salt marsh and sand dune plant communities, and large eelgrass beds are therefore common. The many inlets provide overwintering habitat for waterfowl. The system of sheltered inlets and rocky shore provides habitat for southern and northern faunal species respectively, and periodic summer incursions of slope waters introduce exotic tropical species to this area.

Halifax is a major seaport with large volumes of traffic including container vessels, passenger cruise ships, coast guard and naval traffic. Many industries are located along the shoreline and there is little domestic sewage treatment. Fishing remains an important economic activity for some communities in Unit 5 and includes fisheries for lobster, clam, cod, and haddock. There is an aquaculture lease for blue mussels in Jeddore Harbour (NSDAF 2005). Recreational use in Unit 5, includes bird watching, hiking, camping, whale watching, boating, marinas and recreational beach use.

Unit 6 – Clam Harbour to Liscomb

Unit 6 is part of HRM (Figure 1-5). This area has a submerged, rocky coastline and a series of elongated offshore islands The majority of coastal habitat is rocky shore, with some small beach and salt marsh areas. The rocky shores, especially the quartzite shoals, have extensive seaweed beds. The many islands provide habitat for waterfowl and seabirds (Davis and Browne 1996b) including the Eastern Shore Islands Wildlife Management Area.

There is a limited lobster fishery and developing sea urchin and crab fisheries in this region. Forestry products are processed and shipped out of Sheet Harbour (Davis and Browne 1996b). There are many aquaculture operations within Unit 6 including Ship Harbour, Pope's Harbour, Quoddy Harbour and Marie Joseph Harbour (NSDAF 2005).

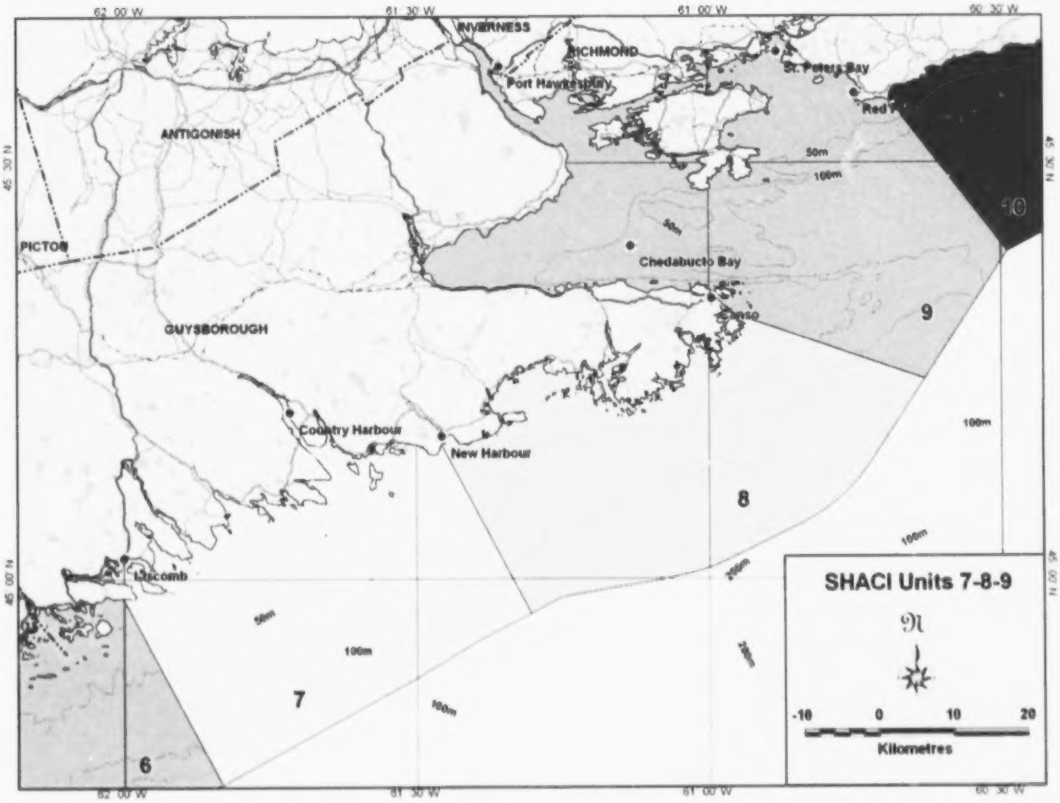

Figure 1-6: SHACI Units 7, 8 and 9

Unit 7- Liscomb to New Harbour

Unit 7 (Figure 1-6) has a submerged coastline with long, narrow, perpendicular bays separated by greywacke headlands. The sheltered inlets and islands in this area provide important habitat for seabirds, shorebirds and waterfowl. The colder water along this coast allows for little diversity in marine fauna. Freshwater runoff from the many rivers emptying here creates estuarine conditions and strongly influences the distribution of brackish water species. There is a limited supply of coastal sediment and beaches are typically rocky or cobbly with few sandy beaches. There are few tidal marshes due to the lack of sediment, nonetheless some eelgrass beds are found.

Settlements in this area are sparse. Recent developments have been spurred by the activities of the offshore oil and gas industry. Natural gas comes ashore at Country Harbour and is carried by pipeline to other parts of the province and beyond.

There are Aquacultire operations throughout this Unit in Liscomb Harbour, Wine Harbour, Indian Harbour and Country Harbour (NSDAF 2005).

Unit 8 – New Harbour to Cape Canso

This area consists of granite knolls that rise above the upland surface (Figure 1-6). The northern coastline is straight, while the southeastern coastline is indented with many bays and islands. Coastal sediment supplies are extremely limited. Rocky shores provide good substrate for rockweed and kelp growth. The cold water shore is little influenced by slope water, leading to little diversity in marine fauna.

Canso was once an important base for fishing fleets that fished the Atlantic fishing banks. Lobster is now the major coastal fishery, however the shrimp and sea urchin fisheries are becoming more important. Aquaculture operations are located in Tor Bay and Whitehead Harbour in Unit 6 (NSDAF 2005). Ecotourism is also increasing in this area.

Unit 9 –Cape Canso to Red Point (Chedabucto Bay)

Chedabucto Bay is the largest bay on the Atlantic Coast of Nova Scotia (Figure 1-6). It was formed by the drowning of an ancient river system that had developed on erodable Carboniferous sediments. Some southern marine fauna species are found here since water temperatures are warmer than on the more exposed coast to the northeast and southwest. The interaction of these species with those of the Southern Gulf of Saint Lawrence has been restricted since the construction of the Canso Causeway in 1955. Fishers attributed the drop in lobster and herring fisheries to the causeway. Drumlins are common in the eastern part of the bay. Marine erosion supplies ample coastal sediment for the many small gravel beaches, which often enclose small lagoons or salt marshes. The salt marsh and estuary areas provide wading bird habitat. Significant winter ice action in this area restricts the growth of seaweeds, the diversity of epifauna as well as winter feeding by waterfowl and seabirds. Whales are occasionally seen in Chedabucto Bay.

The River Inhabitants area is an important nesting area for wood turtles. Isle Madame, the large island in Chedabucto Bay, has salt marshes and is being promoted for tourism. St. Peters Bay is the gateway to the Bras d'Or Lakes and 1200 – 1500 recreational vessels travel through St. Peter's Canal every year. Port Hawkesbury is an industrial centre with a pulp and paper mill and an oil refinery. Small-scale lobster, sea urchin, shrimp and marine fish operations occur in the bay. Aquaculture operations are located in Chedabucto Bay, Strait of Canso, Inhabitants Bay, Lennox Passage, Janvrin Island area and Arichat Harbour (NSDAF 2005). A major oil spill polluted half of Chedabucto Bay's coastline in 1970, however, little evidence of the spill remains today.

Unit 10 – Red Point to Scatarie Island

Unit 10 is located on Cape Breton Island (Figure 1-7). This coastline is relatively even and dips into the sea, except in Gabarus Bay where sea cliffs are found. The sediment supply along the coast is variable. Rocky shores, boulders and cobble beaches are common north of Gabarus, while south of Gabarus, the coast is indented with protected bays. There are numerous sand, gravel and cobble beaches as well as barachois ponds.

Some tidal marsh and eelgrass beds are found, as are some marine floral species from the Gulf of Saint Lawrence. Seaweeds are generally restricted, however, by the cold water and ice action. The cold water in Unit 10 also results in an impoverished marine fauna. Waterfowl, shorebirds and their habitats exist in coves and islands. Areas of deepwater upwelling attract seabirds. Harbour seals are common here, and Grey seals formerly bred on the Basque Islands.

The coast is sparsely populated with scattered fishing villages. Lobster is the most important fishery, and salmon and trout fishing occur in the Mira River. Sand and gravel was extracted from the Mira River in the past.

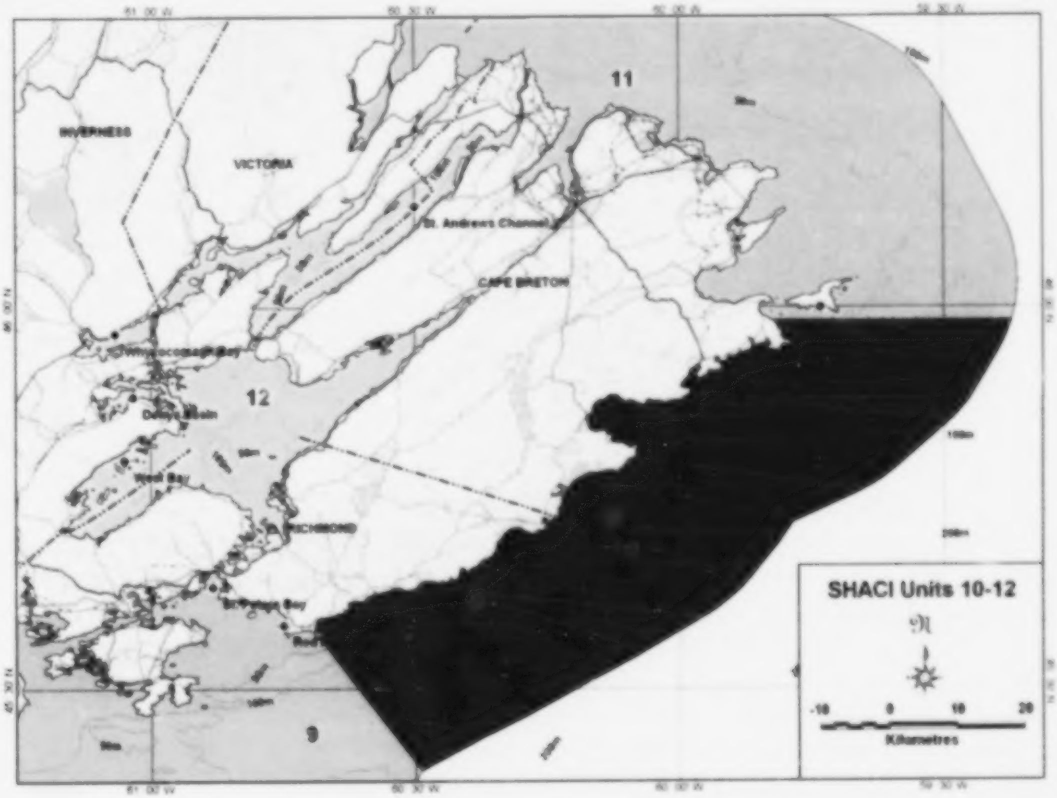

Figure 1-7: SHACI Units 10 and 12

Unit 11 – Scatarie Island to Cape North (Sydney Bight)

Unit 11 includes Sydney Bight and its bordering coastline (Figure 1-8). From Scatarie Island to Cape North, coastal waters are underlain primarily with Carboniferous rocks of the Maritime plain. In the Sydney Basin, there are coal formations that extend from the onshore to Newfoundland. In northern areas, where the Cape Breton Highlands rise up from the sea, nearshore rocks are igneous. The bottom of Sydney Bight is relatively flat and slopes gradually to form St. Anns Bank. At depths less than 100 metres, sediments are a thin layer of sand and gravel mixtures through which bedrock is exposed. Material eroded from the coastal bedrock forms nearshore deposits, and local hydrographic conditions have resulted in the development of sand, gravel or clay deposits in some areas.

In the summer, Sydney Bight is influenced by the fresher, warmer waters flowing in from the Gulf of St. Lawrence. In the winter and spring Sydney Bight is exposed to sea ice moving out of the Gulf of St. Lawrence. Common seaweeds are present at shallow depths, including kelp, rockweed and Irish moss. Atlantic cod form wintering concentrations in deep water before migrating to the Southern Gulf of St. Lawrence to spawn in the spring. Many seabirds are found in the offshore waters.
Lobster is the major fishery, however snow and rock crab, groundfish, capelin and herring are also fished. There is significant industrial traffic in Sydney Bight with the transportation of coal and the ferry service to Newfoundland.

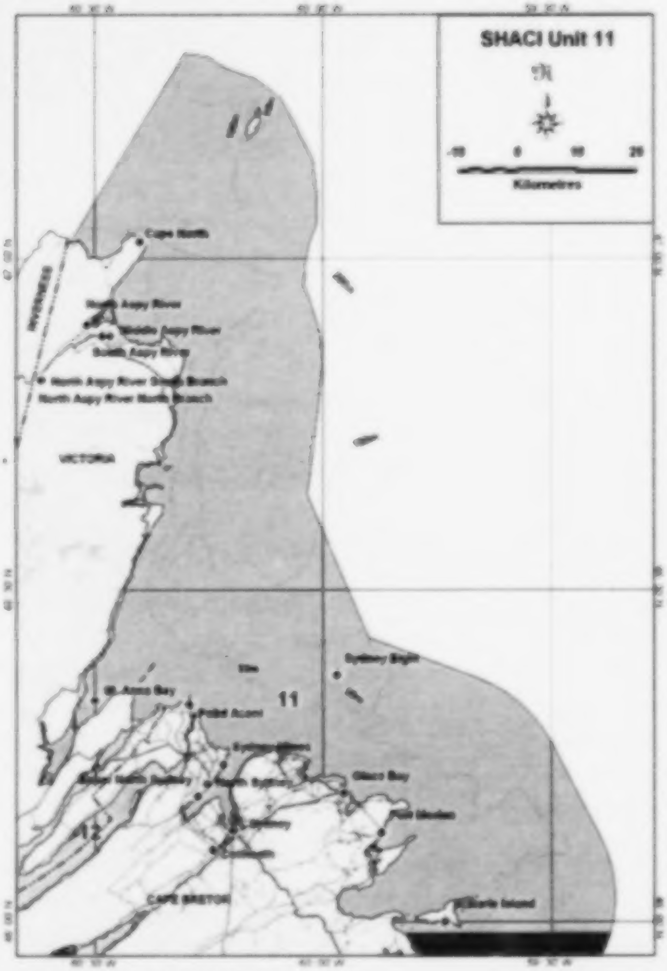

Figure 1-8: SHACI Unit 11

Between Port Morien and Point Aconi the coast consists of sandstone with exposed coal seams. Plant fossils can be found in the shales along the beach. Port Morien, Glace Bay and Lingan Bay have salt marshes with eelgrass beds, and ice scouring limits the growth of marine algae. Sheltered bays and beaches found along the coast provide important habitat for shorebirds and waterfowl. Small islands, particularly the Bird Islands located off Point Aconi, provide nesting areas for colonial seabirds. Along the coast northwest of Sydney, there are bays and inlets to the Bras d'Or Lakes. A large portion of this area is taken up by urban land use. At Coxheath, there are numerous sand and gravel deposits that are commercially exploited, and the notoriously toxic Sydney tarponds are also located in this area.

From St. Anns Bay to Aspy River there are small tidal marshes and scattered barachois ponds. There is a diverse aquatic fauna in the barachois ponds behind barrier beaches, however, winter ice scour restricts the growth of marine algae. Lobster, mackerel and crab fisheries are the economic focus in this region. Numerous aquculture operations are underway in the embayments of this Unit including St. Anns Harbour, Aspy Bay, Mira Bay and Great Bras d'Or Arm (NSDAF 2005).The Cabot Trail and Cape Breton Highlands National Park are major tourist and recreational attractions.

Unit 12 – Bras d'Or Lakes

Unit 12 includes the Bras d'Or Lakes (Figure 1-7). The Bras d'Or Lakes are an irregular brackish body of water covering 260 km^2, surrounded by land, which is in turn surrounded by a larger ocean. The western section of the Lakes is shallow with sheltered bays that include West Bay, Denys Basin, and Whycocomagh Bay. East Bay, St. Andrews Channel, and Great Bras d'Or Channel are the three long, narrow arms to the east. The Lakes connect to Sydney Bight at Great Bras d'Or Channel which is 8 m deep and at Little Bras d'Or Channel which is 6 m deep. A small man-made canal with locks connects the Bras d'Or Lakes to St. Peters Bay.

The lakes lie on regional lowland that developed in soft Carboniferous rocks prior to the Quaternary glacial period. Sedimentary rocks, including shale, sandstone, gypsum, and salt, therefore likely underlie the lakes. Deep channels within the Bras d'Or were probably caused by glacial erosion occurring throughout the Quaternary period. The lake floor morphology is influenced by the deposition of glacial till and pre-glacial silty muds. In the central and western part of the lakes there are drumlins, and there are recessional moraines present in East Bay, St. Andrews Channel and Great Bras d'Or.

Mud sediments are found in most deep areas of the Bras d'Or Lakes, with the exception of the sandy sediments found in areas flushed by tidal currents. Shallow, more exposed western areas of the lake are floored by gravelly-sandy mud that resulted from the erosion of glacial till. Many sandy and gravelly barrier beaches and spits formed due to the coastal erosion of glacial sediments.

Salinity levels in the Bras d'Or Lakes are relatively low, ranging from surface water concentrations of 29 ppt at the entrance to Great Bras d'Or to 20-21 ppt at the east end of East Bay. These low salinities are due in part to the reduced tidal influence and the high levels of fresh water runoff from local rivers. Tidal effects are reduced in the Bras d'Or because connection to the sea is only via two restricted channels.

A 10-20 m thermocline and halocline develop during the summer that is probably deeper in the winter. Lake water is a mix of Atlantic water and local runoff, with little contribution from groundwater. The lake is mostly ice-covered in the winter, and warms by more than 10 C between May and July. Circulation in the Bras d'Or Lakes is typically estuarine with brackish near-surface water that flow seaward and deeper saline water that flows into the lake. Tidal currents at the entrance to Great Bras d'Or range between 4-6 knots. Other currents in the lake tend to be weak. In narrow passages between basins, flow may reach 1 knot. Sizeable waves and swells can develop during northeast gales in the eastern arms of the Bras d'Or Lakes.

Seaweed species found in the Bras d'Or Lakes are similar to those in the Gulf of St. Lawrence, and, as in the Gulf, they are restricted to deeper water due to winter ice activity. Marginal salt to freshwater marsh vegetation is found in the many sheltered bays. A variety of northern and southern fauna are found in the Bras d'Or Lakes. The American oyster occurs due to the warmer water temperatures required for growth and reproduction, and sand shrimp, a southern species, is also found here. The polychaete fauna includes Virginian species as well as some Arctic-boreal species. The fish fauna includes blueback herring, black-spotted stickleback, a southern population of Greenland cod, and a feral population of rainbow trout.

The Lakes are economically important to all residents and of high cultural importance to the First Nations who comprise over 30% of the Lakes residents. Five reserves are located around the lakes: Membertou, Eskasoni, Chapel Island, Wagmatcook and Waycobah. Eskasoni is the largest and most active in the environmental sector.

The Bras d'Or Lakes area includes numerous human resource uses including commercial and recreational fishing, aquaculture, tourism, forestry, agriculture, mining, recreational hunting, recreational boating, commercial shipping, road and rail transport. Just outside the Lakes watershed, heavy industry has developed and future development will undoubtedly add to these current uses. The commercial fishing activity includes lobster and herring fisheries; however, oyster and to a lesser degree salmonid aquaculture is the most important fishing industry. A gypsum mining operation occurs on the lake shore near Little Narrows and the product is shipped out through St. Patricks Channel, the Great Bras d'Or Channel and over Middle Shoal outside Big Bras d'Or. The Bras d'Or Lakes are also a popular recreational boating area; between 1200 -1500 vessels visit these waters every year.

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Methodology

Phase 1 - Guide to significant habitats

Phase 1 involved defining and outlining specific criteria for the selection of significant habitats in the form of a Guide to Significant Habitats. Various established criteria for the conservation of environmentally sensitive areas, marine protected areas, and other types of designation were adapted to meet the overall goals of SHACI. These criteria are listed in the SHACI Criteria section that follows.

Phase 2 - Information collection

Phase 2 involved compiling information about the ecological, cultural and recreational features present in the SHACI study area from materials collected in the literature search, through interviews, and from maps and GIS data layers.

Key literature regarding the Atlantic coast of Nova Scotia (e.g., P. Lane and Associates 1992, Davis and Browne 1996a, Davis and Browne 1996b, Kenchington 1998) as well as any documents describing the study area were examined. Individual features such as physical characteristics (geology, oceanography, chemistry, and climate/weather), marine life (plankton, benthos, fish, birds, mammals, marine plants) and marine habitats (salt marsh, estuaries, sand beaches, mudflats, offshore islands, spawning and nursery areas) were noted with the overall goal being to identify significant habitats associated with these features.

To complement and enhance the information collected in the literature review, Phase 2 involved conducting interviews with individual scientists within DFO, universities and research institutes, members of community organizations, and other individuals with information about Atlantic coast habitats. Phase 2 is an ongoing process. As the SHACI initiative continues, new contacts will be made and new information about significant habitats will become available.

Phase 3 - Unit overview

Phase 3 involved compiling the information collected during the first two phases to create a coherent document providing information about SHACI Units 4-6 ecological and cultural/recreational values. The SHACI Units 4-6 document is divided into sections and includes maps of important ecological and cultural/recreational features.

Phase 4 - Significant habitat selection

To select significant habitats, the SHACI Units 4-6 document was reviewed using the criteria established in the Guide to Significant Habitats section. Any ecological or cultural/recreational feature or attribute mentioned in the overview was noted. The data was sorted to be grouped by location. In this manner, locations or areas with several significant attributes became apparent.

Such areas, as well as areas with particularly important features (e.g., habitat for species at risk) are considered more significant and are selected as significant habitats.

Phase 5 - Significant habitat descriptions

Ideally, a detailed summary should be provided for each area selected as a Significant Habitat. The detailed summaries include written descriptions and maps of the location, habitat, and the ecological and/or cultural and recreational features which make the area significant. The Guide to Significant Habitats can be used again at this stage to ensure that areas selected do meet with the established guidelines. This phase may also look more closely at different methods for the analysis of the data to assess the significance of areas.

Phase 6 - Review

To ensure that the information presented in the SHACI Units 4-6 document is correct and that the areas selected as significant habitats are accurate and reflect the local knowledge and values, a review of the maps and documents generated by SHACI was required. Each chapter within the document was reviewed by one or more people working in that field.

2 - SHACI criteria

SHACI as a guide to significant habitats

Purpose and scope

Significant habitats can be identified and assessed according to selected ecological and cultural attributes. These attributes are not intended as strict rules or criteria in which future protection (e.g., the establishment of MPAs) will be judged. SHACI is intended as a guide that defines 'significant habitats', and outlines the suggested ecological and cultural/recreational attributes that should be used to identify significance in each Unit area. Identifying these attributes will help guide future decisions and ensure that sites are identified and assessed on a consistent and balanced basis.

Internationally, and in Canada, a large number of approaches and criteria have been developed to examine the sensitivity or importance of an area, or the selection of MPAs,(e.g., International Union for the Conservation of Nature (IUCN). This guide was initially developed based on these broad information sources, and modified based on internal discussions within DFO.

This guide recognizes that it will sometimes be necessary to conduct evaluations on the basis of qualitative judgements. In such cases evaluators should take care to render such judgements as explicitly as possible, and set forth their assumptions and findings with a view to facilitating further discussion.

This guide recommends the use of the precautionary approach, established in the *Oceans Act*, in the selection of significant habitats. This approach requires that the best information available be used to identify and protect areas that may need protection. This approach also recognizes the value in reconsidering decisions, as further information becomes available. For example, a site may be rated highly as a unique habitat because, given the present state of knowledge, no comparable habitat is known to exist anywhere else within a region. Later, when more comprehensive habitat studies become available, this rating could be reviewed. Similarly, the importance of an area may increase if it is habitat to a species that becomes classified as endangered.

Definition

For the purposes of SHACI, the definition of a **significant habitat** is:

> **Any area of land or water within the territorial sea and internal marine waters of Canada, large or small, under private or public control, that has desirable ecological and/or cultural and recreational attributes. These ecological attributes contribute to the functioning and sustainability of the coastal ecosystem, the conservation and protection of genetic, species, population and/or habitat diversity, and/or other similar vital ecological**

functions. The cultural and recreational attributes contribute to the health and well being of coastal communities, the conservation of historical and traditional cultures, and other components valued by coastal communities.

Significant habitat complexes may be identified. These are significant habitats that are either contiguous or in relatively close proximity to each other so as to allow their recognition as a single, interrelated ecological unit. Habitat complexes may be either:

- contiguous similar habitats (e.g., linear stretches of beaches or dunes running parallel to the coast); or
- contiguous dissimilar habitats that may be geomorphologically or ecologically related (e.g., barrier beach/lagoon/saltmarsh complexes); or
- discontinuous but not necessarily remote similar habitats that form an essential part (if not the entirety) of a species' population or metapopulation.

While a rating, or weighting system can be useful in evaluating whether particular sites are suitable for a particular designation (e.g. MPA status), no formal weighting system is designed to determine significant habitats, other than to recognize that areas with Species at Risk are particularly important.

Significant habitats are recognized according to one or more of the attributes listed below. Areas possessing more than one attribute are considered more significant, but no formal rating system is used for evaluation.

Ecological attributes

Significant habitats are identified and assessed in the following terms:

General

- **Diversity**: the variety or richness of ecosystems, habitats, communities and species. Areas with more diversity are considered more significant.

- **Naturalness**: the lack of disturbance or degradation. Natural areas are of more value to fisheries and tourism and make greater biological contributions to the ecosystem. Natural areas are considered more significant.

- **Dependency**: the degree to which a species depends on an area or the degree to which an ecosystem depends on ecological processes occurring in the area. Areas critical to one or more species or process are considered more significant.

- **Representativeness**: the degree to which an area represents a habitat type, ecological process, biological community, physiographic feature or other natural characteristic. A habitat type that has not yet been protected is considered more significant.

- **Uniqueness**: an area that is "one of a kind" (e.g., habitats of endangered species occurring only in one area) because of its process, ecology, features or one of a kind because of its naturalness.

- **Productivity**: the degree to which productive processes within the area contribute benefits to species or to humans. Areas that contribute most to ecosystem sustainability are considered more significant with the exception of eutrophic areas where high productivity has negative effects.

- **Vulnerability**: the area's susceptibility to degradation by natural events or the activities of people. Biotic communities associated with coastal habitats may have a low tolerance to changes in environmental conditions, or they may exist close to the limits of their tolerance. Areas that are more vulnerable are considered more significant.

Ecological conservation and protection

Areas are considered significant if they are important for the conservation and protection of:

Ecological areas of cultural or community significance
- Areas identified as significant ecological areas by Aboriginal communities as identified through the gathering of traditional knowledge
- Areas identified as significant ecological areas by the fishing community or other non-Aboriginal communities through the gathering of traditional ecological knowledge
- Areas identified through science or the scientific literature as ecologicallyor biologically significant

Commercial fisheries resources (fish and invertebrates)
- The area supports habitat critical to certain life stages or aggregations of target species (e.g., spawning areas, juvenile areas, overwintering areas, and feeding areas)
- The area is a key component of a migratory route
- The area contains unique or vulnerable genetic stocks of target species
- The area provides critical habitat or an ecosystem function or process important to the survival of a single species or group of species

Non-commercial fishery resources (marine mammals, turtles, birds, fish, invertebrates, etc)
- The area supports habitat critical to certain life stages or aggregations of species during some part of the year (e.g breeding, calving, feeding, spawning, juvenile, nesting, resting, overwintering)
- The area supports an endangered, threatened or vulnerable population or species as indicated by COSEWIC
- The area is a key component of a migratory route
- The area is vulnerable to human disturbance
- The area supports concentrations of more than one species
- The area provides critical habitat or an ecosystem function or process important to the survival of a single species or group of species

Endangered or threatened species and habitats

- The area supports concentrations of endangered, or threatened species identified on international, national or regional lists of concern
- The area supports key breeding/nesting/calving/birthing habitat for these species
- The area contains endemic, relict, or edge range populations
- The area is vulnerable to human disturbance

Unique habitats

- The area is "one of a kind"
- The area is sub-regionally, regionally, nationally, or internationally rare
- The area provides unique habitat for species or community assemblages
- The area provides unique biogeographic or ecological habitat qualities
- The area contributes to a unique ecosystem process
- The area is a centre of endemism or of rare species unique to a single habitat area
- The area contains a unique geological feature that supports unique associated species or ecological communities/assemblages

High biodiversity

- The area supports a variety or richness of ecosystems, habitats, communities, species, and/or populations
- The area has high genetic diversity (within species)
- The area is diverse compared to areas exposed to similar environmental forces
- The area contains one or more habitats or features characteristic of high species diversity (e.g., estuaries, upwelling areas, continental slope, etc.)
- The area supports high variability among species, community types and ecosystem processes
- The area is vulnerable to human disturbance

High biological productivity

- The area contains one or more habitats or features identified as characteristic of high productivity (estuaries, upwelling areas, etc.)
- The area generates large biomass
- The area supports species that are indicators of productivity (e.g., high phyto/zooplankton, marine mammal concentrations, etc.)
- The area is vulnerable to human disturbance

Scientific research

- There are existing, planned and/or possible research activities or surveys within the subject area
- The area could serve as a benchmark for scientific monitoring
- The area's natural functions and ecosystems are relatively intact
- The area could foster better understanding of natural systems
- The area contains a variety of habitat types and ecosystems processes that may be relevant for research

Existing or possible designations that protect ecological values

- The area has a national or international designation (e.g., Biosphere Reserve, World Heritage Area/Site) or is the subject to an international agreement
- The area has existing or potential value to local , regional, national and international conservation efforts
- The area is recognized by local authorities as representing a site of regional or local ecological significance
- The area is recognized by other federal or provincial protected area or restricted land use designations
- The area is currently recognized informally as a key area for some ecological feature

Cultural and recreational attributes

SHACI also considers cultural and recreational values. Areas that possess the cultural and recreational attributes listed below are considered more significant.

General

- The features or assets of the area contribute to the economic and social well being of coastal communities, including Aboriginal communities
- The area is regularly used by residents of local communities for community purposes, (e.g., recreational uses, anchorage, gatherings etc.)
- Areas with cultural and spiritual significance to Aboriginal Communities as identified through the gathering of traditional knowledge
- Areas with cultural or spiritual significance to coastal communities as identified through the gathering of traditional ecological knowledge
- The area supports a traditional food fishery that is part of the local culture
- The area contains significant aesthetic, cultural, religious, or heritage features or resources, e.g., seascape or landscape vistas, archaeological sites, wildlife viewing, shipwrecks, and traditional food collection
- The area is important for social, cultural, religious, or traditional activities
- The area provides the local community the opportunity to use, enjoy and learn about their local environment
- The area offers particularly important education and public awareness opportunities for coastal or marine issues

Existing or possible designations that protect cultural/recreational values

Local authorities recognize the area as representing a site of regional or local cultural or recreational significance
The area is recognized by other federal or provincial protected area or restricted land use designations
The area is currently recognized informally as a key area for some cultural or recreational feature

Socio-economic considerations

Socio-economic considerations are not criteria by which a Significant Habitat is selected or evaluated. Rather, they are factors to consider should the identification of a Significant Habitat warrant a protected status for the area, or the development of an integrated management plan with the local community. The following questions should be asked when considering socio-economic issues:

- Do commercial, recreational, or subsistence fishers use the area and do they depend on it?, and are dependent on the area. The species fished and gear type used should be considered. Is this fishery compatible with the ecological, cultural and recreational attributes of the significant habitat?
- Does the economy of the area depend on industry? Is this industry compatible with the ecological, cultural and recreational attributes of the significant habitat?
- Would some degree of protection or management affect the local community in the long-term?
- What is the existing or potential value of the area to tourism development? Are these developments compatible with the ecological, cultural and recreational attributes of the significant habitat?
- Is increased management or protection socially and politically acceptable? Is there community support?

3 - HRM overview – SHACI Units 4-6

The remainder of this document focuses on SHACI Units 4-6, the Halifax Regional Municipality (HRM) area (Figure 3-1). SHACI Units 4-6 include coastal waters extending from Blandford, Lunenburg County to Liscomb, Guysborough County.

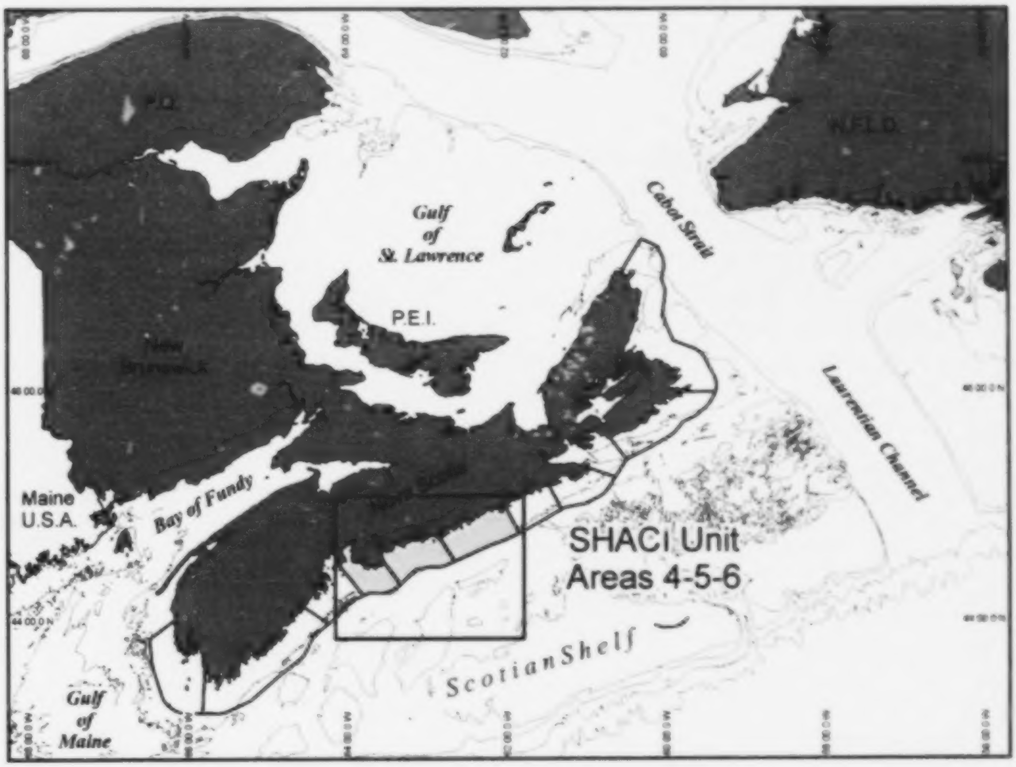

Figure 3-1: Regional context of SHACI Units 4-6 study area

SHACI Units 4-6 are characterized by a rocky coast with a complex shoreline of inlets, islands, reefs and embayments. The complex nature of the shoreline allows for extensive salt marshes in the area, particularly in Unit 5. HRM, which contains all of Unit 5 and the majority of Units 4 and 6, has the most wetlands of any county in the province although other counties contain more wetland area (Hanson and Calkins 1996). Of the coastal wetlands in the County, estuarine flats comprise the largest area. Most of the extensive coastal wetlands in SHACI Units 4-6 occur in Unit 5, including Musquodoboit Harbour and Cole Harbour.

The rugged, exposed rocky shores provide excellent habitat for a variety of flora and fauna. Highly productive macroalgae are found in St. Margarets Bay. SHACI Units 4-6 encompass important spawning areas for several species of fish, including cod, pollock, haddock and herring. Juvenile cod are found all along the coast of the study area and juvenile pollock are found in St. Margarets Bay. Marine bird breeding colonies are scattered across Units 4-6, with a few well-recognized concentrations between Halifax and Clam Bay. Seal haulout areas are also

3 - HRM overview – SHACI Units 4-6

The remainder of this document focuses on SHACI Units 4-6, the Halifax Regional Municipality (HRM) area (Figure 3-1). SHACI Units 4-6 include coastal waters extending from Blandford, Lunenburg County to Liscomb, Guysborough County.

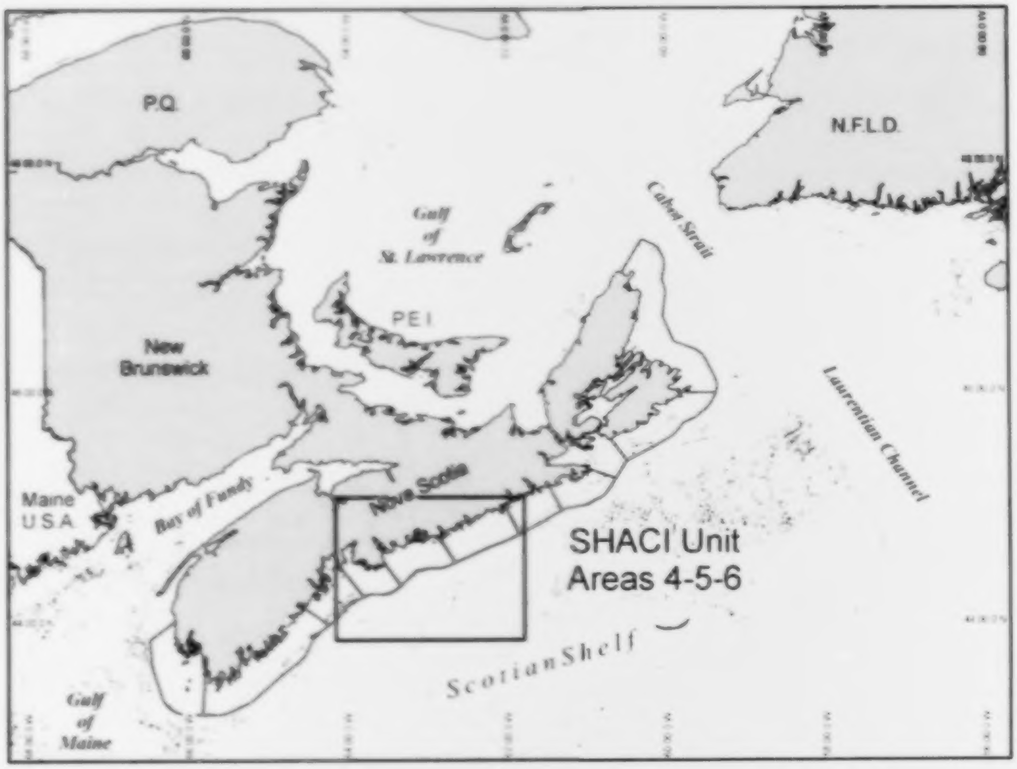

Figure 3-1: Regional context of SHACI Units 4-6 study area

SHACI Units 4-6 are characterized by a rocky coast with a complex shoreline of inlets, islands, reefs and embayments. The complex nature of the shoreline allows for extensive salt marshes in the area, particularly in Unit 5. HRM, which contains all of Unit 5 and the majority of Units 4 and 6, has the most wetlands of any county in the province although other counties contain more wetland area (Hanson and Calkins 1996). Of the coastal wetlands in the County, estuarine flats comprise the largest area. Most of the extensive coastal wetlands in SHACI Units 4-6 occur in Unit 5, including Musquodoboit Harbour and Cole Harbour.

The rugged, exposed rocky shores provide excellent habitat for a variety of flora and fauna. Highly productive macroalgae are found in St. Margarets Bay. SHACI Units 4-6 encompass important spawning areas for several species of fish, including cod, pollock, haddock and herring. Juvenile cod are found all along the coast of the study area and juvenile pollock are found in St. Margarets Bay. Marine bird breeding colonies are scattered across Units 4-6, with a few well-recognized concentrations between Halifax and Clam Bay. Seal haulout areas are also scattered throughout the study area. Waters in SHACI Units 4-6 are part of the migration pathway taken by humpback and blue whales to the Gulf of St. Lawrence or points further north.

Several species at risk are found within the study area. Endangered species, including the Roseate Tern and Piping Plover use beaches within the study area for breeding.
Roseate Terns typically nest on small offshore islands and islets such as Fisherman's Beach, Sambro Island and Wedge Island along the Atlantic coast of Nova Scotia. The Piping Plover nests on Martinique Beach. Local inshore populations of the Maritimes population of Atlantic cod, a species of special concern, exist along the coast of SHACI Units 4-6, including a group that occurs within the approaches to Halifax Harbour from early fall to early winter (Fanning pers. comm. 2003).

SHACI Units 4-6 are busy areas for transportation, fisheries, aquaculture facilities and tourism. There are several pelagic, groundfish and invertebrate fisheries as well as 29 aquaculture sites (NSDAF 2005). Halifax (Unit 5) is one of Canada's largest commercial ports, handling over 14 million metric tonnes of cargo in 1999 (Halifax Port Authority 2004a). It has one of the world's deepest and largest natural harbours (Halifax Port Authority 2004b).

The Halifax-Dartmouth area (Unit 5) grossed the highest tourism generated revenues of all regions in Nova Scotia in 2002 (Government of Nova Scotia 2003). Within SHACI Units 4-6, popular tourist attractions include parks, beaches, historic sites and hiking trails. The study area also has two important sites for whale watching: St. Margarets Bay and the approaches to Halifax Harbour.

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Coastal environments

Coastal environment overview

The Atlantic coast of Nova Scotia is a rocky coast that follows the regional southwesterly-northeasterly Appalachian trend (Owens and Bowen 1977). With the exception of the Cape Breton Highlands, most of the coast is low-lying with drowned metamorphic and igenous rocks, resulting in an intricate shoreline of islands and bays. The Atlantic coast of the mainland is characterized by resistant white rock outcrops and high wave-energy conditions. This situation is true in SHACI Units 4-6 which lie within one of the most homogeneous subdivisions in the Maritime provinces.

Along the Atlantic coast of mainland Nova Scotia and in SHACI Units 4-6, post-glacial sea level rise has drowned the lowland coastal area, producing a complex shoreline of inlets, islands, reefs and embayments (Owens and Bowen 1997). There is a general scarcity of sediments in this region but embayments have been closed by barriers, spits and tombolos in areas where material is available for reworking. Beaches of sand have been developed (e.g., Martinique Beach) where sediment is available locally or where material has been moved landward with the rising sea level.

The exposed wave-energy environment experiences increased energy levels in the winter (Neu 1972). The marked difference between wave energy levels in summer and winter months causes a cycle of summer accretion and winter erosion along beaches (Owens and Bowen 1977). The complex nature of the shoreline allows for extensive salt marshes in the area.

The numerous bays and inlets in the region vary in size and characteristics. Large bays such as St. Margarets Bay (Unit 4) have marine environments similar to the conditions of the offshore (Davis and Browne 1996). Oceanic organisms such as jellyfish and pelagic fish frequently enter the bays and seaweed populations can be widespread. Although they may receive influxes of fresh water from coastal streams, the bays are not estuarine.

Most harbours and inlets were formed as a result of submergence of river valleys (Davis and Browne 1996). Physical conditions in coastal waterbodies are generally warmer, more estuarine, more sheltered and have less wave exposure than exposed sections of the ocean coastline. As a result, animal and plant communities in these areas differ from those found on the open coast.

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4 - Geology

Subsurface geology and associated features

King and MacLean (1976) subdivided the physiography of the Scotian Shelf into three zones based on morphology, underlying bedrock and sediment type: an inner zone characterized by rough topography, and corresponding central and outer zones.

The inner zone borders Nova Scotia and extends seaward about 25 km to a depth of 100 to 120 m along the fall zone, approximately matching the seaward boundaries of the SHACI study area. This area of the shelf belongs to the tilted Atlantic Uplands, a geomorphic division of the Appalachian Region. Its surface bears many similarities to that of the adjacent land areas and reflects the degree of roughness of the underlying bedrock surface. The inner shelf has experienced a much longer history of geomorphic development than its corresponding central and outer regions.

Bedrock underlying SHACI Units 4-6 is comprised of undivided rocks of Cambrian-Devonian origin. These rocks form an acoustic basement, through which the energy of seismic reflections does not pass. They consist of two overlapping geological formations: the underlying Meguma Group is composed of greywacke, quartzite and slate, and the overlying layer is Halifax Formation slate (King and MacLean 1976, Fader 1991). Between Halifax Harbour and Liscomb Harbour, the bedrock is tightly folded, with closely spaced ridges of low to moderate relief parallel to the coastline (Loncarevic et al. 1994, Davis and Browne 1996).

The seabed of the Scotian Shelf is dominantly influenced by the effects of wind, waves and currents. The distribution of the most prominent subsurface features that characterize its formations (e.g., current scour, megaflutes, pockmarks, sandwaves, shellbeds, sandribbons, sandridges, megaripples and bedrock outcrops) are well known. Marine geological surveys undertaken by the Geological Survey of Canada – Atlantic (GSCA), its predecessor the Atlantic Geoscience Centre, universities and consulting firms have generated data since compiled into several detailed map series (see for example King and MacLean 1976, Piper et al. 1986, AGC 1991 and Stea et al. 1993). Most of those data, however, are plotted exclusively on large mapsheets and are not readily available in digital form (Fader pers. comm. 2003). Attempts to synthesize these data into a single reference map have not been made, and individual maps are insufficient. It is therefore not possible to provide a map that shows the distribution of bedrock constituents and subsurface features.

Channels are ubiquitous across the Scotian Shelf, and although only a few have been mapped in the nearshore region, more are proposed to exist because the inner shelf is a drowned river system (Fader 1991). Large areas of gas-charged sediments are found in Halifax Harbour and St. Margarets Bay. Although the type of gas is not known for certain, geologists believe it to be methane because the only likely alternative, petrogenic gas, could not have reached these areas through underlying non-sedimentary bedrock (Fader 1991). Sediment thickness is extremely variable across the Scotian Shelf. While the average depth is 50 m, basin bottoms may retain deposits over 100 m thick and many inshore areas have exposed bedrock and no surficial sediments (Fader 1991).

Surficial geology and associated features

The spatial distribution and characteristics of the Scotian Shelf were systematically mapped during the 1960s, 1970s and 1980s by the Geological Survey of Canada (King 1970, MacLean and King 1971, Drapeau and King 1972, MacLean et al. 1977, Fader et al. 1982, King and Fader 1986, Fader et al. 1988, Piper 1991). Industry, university and foreign sources also mapped much of this area (Plasse 1986). Using the available acoustic technology and seafloor sediment samples, the mapping program broadly characterized surficial shelf characteristics. King (1970) differentiated five sedimentary units of quaternary origin on the seafloor: Sable Island Sand and Gravel, LaHave Clay, Sambro Sand, Emerald Silt and Scotian Shelf Drift (King 1970). See Table 4-1 for particle size and characteristics.

Table 4-1: Characteristics of Scotian Shelf quaternary deposits (Breeze et al. 2002)

Deposit	Characteristics
Sable Island Sand and Gravel	Fine to coarse, well-sorted sand grading to coarse angular to rounded gravels (pebble to cobble and boulder size)
LaHave Clay	Greyish brown, soft, silty clay grading to clayey silt (Holocene mud). Contains many foraminifera. Median grain size of 0.003-0.06 mm.
Sambro Sand	Silty sand grading locally to gravelly sand and well-sorted sand. Median grain size of 0.06 - 0.6 mm.
Emerald Silt	Poorly sorted clayey and sandy silt and silty and clayey sand, sometimes with gravel (glaciomarine sediments). Median grain size of 0.05 – 0.01 mm.
Scotian Shelf Drift	Undifferentiated, poorly sorted sediment, sandy with abundant silt and clay and fragments of pebble-to-boulder-size gravel (glacial till).

The surficial sediments of the inner shelf, including SHACI Units 4-6, are mostly sand, gravel ranging from granules to boulders, and exposed bedrock. In most areas surficial sediments are thin, although glacial till has accumulated on bedrock in depressions (Breeze et al. 2002). Fader (1991) produced a comprehensive map showing the distribution of these sediments across the shelf in conjunction with several surficial features, including measured sediment depth and bedrock outcroppings.

The inner zone is predominantly bedrock outcrop (Taylor et al. 1991). Glacial deposits in the inner zone are limited because of non- or limited deposition, the resistant nature of the bedrock, and significant erosion of the glacial deposits by post-glacial marine transgression. Sable Island Sand and Gravel formation is present as a discontinuous veneer over the entire inner zone.

Although we know a good deal about the surficial geology of the Scotian Shelf, most of that knowledge is offshore, seaward of the coastal areas under study in SHACI. Studies have been conducted in some local inshore areas, including Louisburg Harbour, the Guysborough County shore, and most significantly Halifax Harbour. Most of the studies in the latter location have been performed in conjunction with various attempts to enhance the local sewage treatment system, but others have been conducted opportunistically, such as while survey vessels were waiting out storms (Fader pers. comm. 2003).

The offshore focus is due to demand for resource exploration, and little identified demand for inshore studies. Coastal surveys are relatively rare for other reasons too – until recently, survey technology was not very good in shallow water environments, which are also treacherous for navigational reasons. These factors, among others, have precluded a systematic assessment of coastal areas in Nova Scotia and consequently the best available surficial geological map for SHACI Units 4-6 (Figure 4-1) has extremely limited coverage. This is a significant gap in the overall picture of inshore marine geology, and will need to be rigorously addressed to support any forthcoming integrated coastal management schemes.

Surficial Geological Features

Source: G. Fader, L. King, H.W. Josenhans

▨ Sambro Sand: 8a, mainly silty and clayey sand with less than 10% gravel; 8b, sand, silt and clay of 8a, with more than 10% gravel.

□ Sable Island Sand and Gravel: 10a, sand with less than 50% gravel; 10b, gravel with less than 50% sand.

░ Scotian Shelf Drift; Newfoundland Shelf Drift: 6, glacial till, may include some stratified drift.

□ LaHave Clay: 9a, silty clay; 9b, clayey silt; 9c, silty sandy clay and clayey sandy silt grading locally to silty clayey sand, (more than 20% sand).

■ Emerald Silt: 7a, poorly sorted, clayey and sandy silt; 7b, silt of 7a, with gravel.

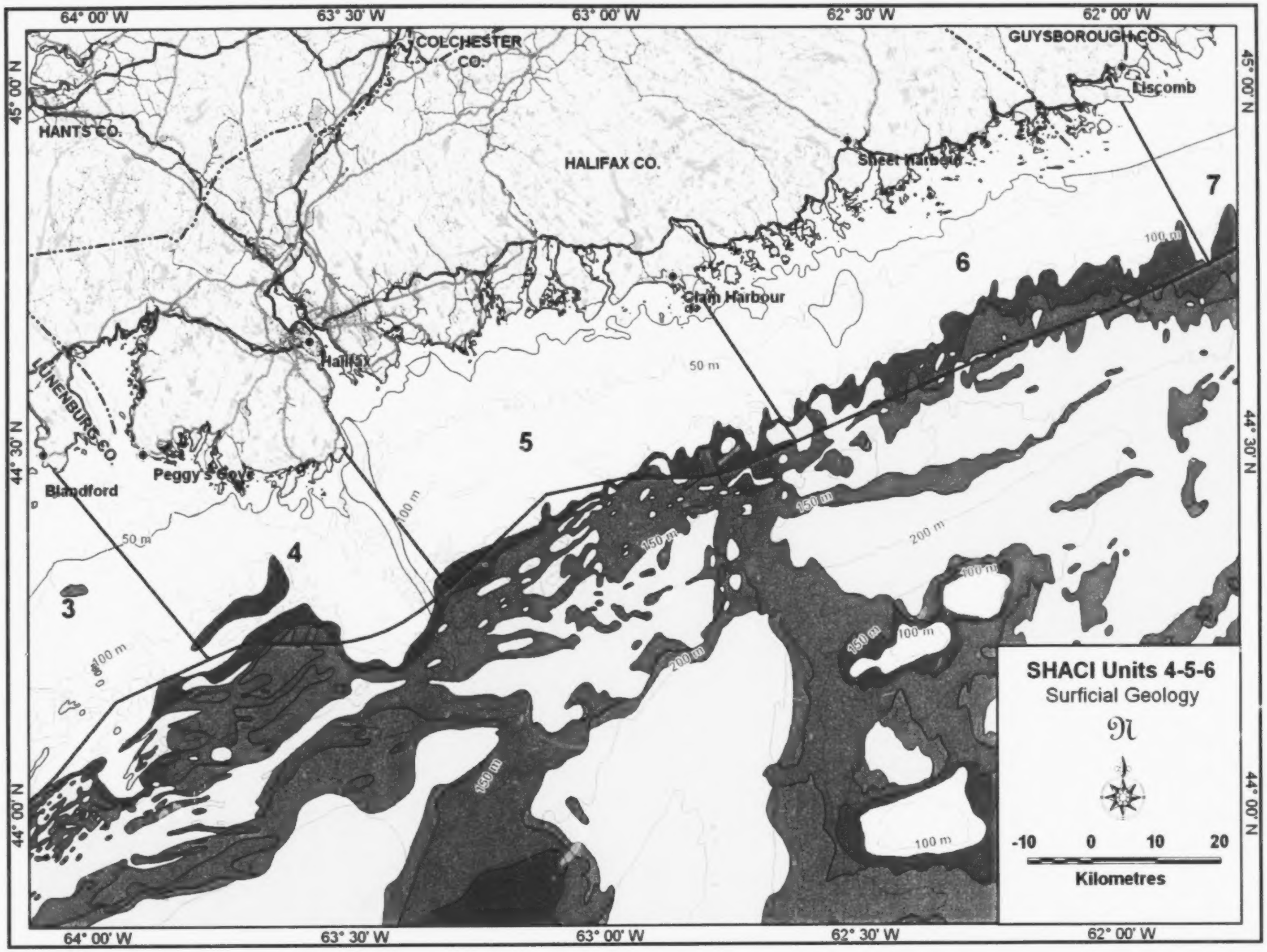


Figure 4-1: Surficial geology of SHACI Units 4-6

Coastal geology

The Nova Scotia coastal zone is a complex and dynamic environment predominantly influenced by wind, waves, tides and long-term transgressive sea level rise (P. Lane and Associates 1992). Most of the coast is composed of predominantly metamorphic and igneous rock that provides little sediment to the shore zone. Its orientation roughly follows the southwest-northeast trends of the Appalachian system, and is therefore exposed to high wave energy levels originating in the western North Atlantic. Coastal relief in much of the HRM coastline is less than 100 m.

Davis and Browne (1996) divided Nova Scotia's Atlantic coast into nine districts based on geomorphological characteristics, two of which pertain to SHACI Units 4-6: Beaches and Islands, and Granite (Pennant) Barrens.

The promontory between St. Margarets Bay and Halifax Harbour comprises the Pennant Barrens. This area is underlain entirely by granite that forms knolls with elevations up to 150 m, well above the surrounding upland surface. Joints within the granite divide it into large blocks, which, at the shoreline, may be loosened and moved by storms to provide dramatic coastal topography. (Davis and Browne 1996)

The granite surface is thinly and patchily covered by granite till, and glacial striations may be seen on many areas of exposed bedrock. The sediment supply is very limited, and beaches such as Crystal Crescent (Unit 4) only occur due to the sufficient accumulation of sediment deposited by the ebbing tide. (Davis and Browne 1996)

Two units of Beaches and Islands are found in the HRM area: Eastern Shore Beaches and Bay of Islands. The Eastern Shore Beaches extend from the western shore of Halifax Harbour to Owls Head, near Clam Harbour, along an indented submergent coastline. The coast is divided into headlands separated by long inlets, most of which are drowned river estuaries and do not appear to be fault-controlled. Porters Lake, stretching inland from Terminal Beach, is an exception, as it occupies a fault zone and appears to be fault-controlled (Davis and Browne 1996). The ground moraine is formed by loose cobbly quartzite till, and is overlain in the Chezzetcook to Lawrencetown and Clam Bay areas by drumlins of red-brown Lawrencetown Till. This young and irregular coastline is slowly being smoothed off as sediment is redistributed through the erosion of deep glacial tills and glacial outwash deposits along the coast. Spits and barrier beaches, formed through the same sediment redistribution, connect promontories and islands and protect the large, shallow estuaries from ocean waves, allowing the formation of salt marshes (Davis and Browne 1996).

The Bay of Islands extends from the headlands of Little Harbour to Liscomb Harbour and north to the head of these and other inlets found between. Coastal topography, including the offshore islands, is a ridge-and-valley pattern, caused by the axis of folds in the bedrock and the drowning of low, eroded headlands during recent coastal submergence. The islands have average elevations of less than 15 m, and drumlins form headlands (but rarely islands) all along the shore of this Unit (Davis and Browne 1996).

Similar to the Atlantic Coast, Davis and Browne (1996) divided the Atlantic Interior into six districts, one of which falls within SHACI Unit 4: Bays (St. Margarets Bay).

St. Margarets Bay and Mahone Bay are ancient landscape features that were formed during a period of rapid erosion before the Carboniferous. During the Middle Carboniferous, an extension of the Carboniferous sea transgressed this part of the old erosion surface and deposited limestone and evaporates. Most of these strata have now been eroded away, and only a fringe is left around the margin of the two bays. Granite is the dominant rock-type in this district (Davis and Browne 1996).

The Slates tend to be covered by fairly deep surficial deposits in the form of glacial tills and drumlins. The drumlin swarms continue into the sea where they form islands. These have been extensively eroded by the sea in recent times to form shoals, spits and bars. Finer sediment is deposited in small salt marshes in the low-energy environments at the head of the bays. Small, sandy pocket beaches are present on exposed coasts at the bay heads, but deep water inland sills at the bay entrances has prevented the rising sea level from moving nearshore sand deposits onto the present coastline (Davis and Browne 1996).

A coastal lowland that developed on Carboniferous rocks around the bays is abruptly terminated by the steep sloping granite inland. On the Aspotogan Peninsula, the till is very thin as a result of the scarcity of softer Carboniferous rocks (Davis and Browne 1996).

Monitoring coastal change

The Geological Survey of Canada (GSCA) has undertaken a number of programs to monitor specific coastal features and to establish a baseline data set for measuring future changes in those features along the entire coast. Among the oldest of such programs is the establishment of fixed coastal monitoring sites, nearly 30 of which are found within SHACI Units 4-6 (Table 4-2). Repetitive observations and surveys provide baseline information about long-term changes in shoreline position, morphology and the impacts of extreme storm events. The information collected at the sites can be used to assess shoreline response to changing natural conditions such as a warming climate and increased storminess, and to human activities near the sites, such as wharf construction or sediment extraction. Repetitive shoreline measurements spanning 15 or more years are available for many of these sites.

Aerial video surveys were also conducted to provide a continuous visual record of both static and dynamic features of the Nova Scotia coastline. The coastline of SHACI Units 4-6 were videotaped between 1989 and 1992, and the videos and accompanying descriptions released as GSC Open File Reports (Taylor and Frobel 1996, 2001). The physical character of coastal subdivisions falling within SHACI Units 4-6 was summarized in the latter of these reports and is provided in Table 4-3.

Table 4-2: Coastal monitoring sites within SHACI Units 4-6 (GSCA no date)

Coastal Monitoring Site Name	Measured Parameters	No. of Surveys*	Last Surveyed
Blandford Head Station A	Clifftop	3	1992
Blandford Head Station B	Clifftop	5	1992
Fort McNab's/Strawberry Hill, McNab's Island	Clifftop and beach	4	2000
Big Thrumcap, McNab's Island	Clifftop, slope and beach	7	2002
Doyle Point, McNab's Island	Clifftop, slope and beach	5	2002
West Gut, McNab's Island	Clifftop, slope and beach	5	2002
Green Hill, McNab's Island	Clifftop, slope and beach	5	2002
Wreck, McNab's Island	Clifftop, slope and beach	6	2002
East Gut, Lawlor Island	Clifftop, slope and beach	3-7	2000
Lawlor Point, Lawlor Island	Clifftop, slope and beach	4	2000
Hartlen Point South	Clifftop and beach	7	1997
Hartlen Point North	Clifftop and beach	9	1997
Cow Bay	Beach	7-11	2000
Conrods Beach	Beach	2-13	1999
Lawrencetown Head	Clifftop	9	1997
Lawrencetown Beach	Beach	6-12	1999
Half Island Point	Cliff top	9	1997
Seaforth	Beach	2	1995
Grand Desert	Cliff top	40	2000
Cape Antrim Beach	Beach	4	2000
Fishermans Beach	Beach	2	1999
Story Head Cliff	Cliff top and beach	12	1999
Long Beach-Miseners Lake	Beach	3-59	1999
Collies Head	Cliff top and beach	9	1999
Philip Head	Cliff top and beach	11	1998
Martinique	Beach	3-6	1999
Clam Bay	Cliff top and beach	5	1997
Back Beach, Sober Island	Beach	1	1991
Fancys Point-Marie Joseph	Beach	4	1999
Pond Beach-Langs Pond	Beach	2	1991

* Many coastal monitoring sites have more than one reference line. Ranges given in the number of surveys indicate that not every reference line is surveyed during each site visit (Manson pers. comm. 2003).

Table 4-3: Summary of coastal units along Atlantic Nova Scotia from Halifax to Liscomb Harbour* (Taylor and Frobel 2001)

Subdivision	Geological character	Coastal relief and plan form	Shore types	Sediment type and abundance
Eastern Shore (Halifax to Clam Bay)	Unconsolidated over resistant meta-sedimentary rocks, drumlins, till cover <30 m	Low, <45 m, Indented, long, narrow estuaries, & headlands	Till cliffs, barriers, spits, beaches, marsh, isolated rock outcrop	Mud to boulder, abundance variable, locally high
Bays of Islands (Clam Bay to Liscomb Island)	Resistant meta-sedimentary rocks, till cover variable <25 m glacio-fluvial deposits	Low <30 m; indented, many islands, peninsulas, few long narrow estuaries	Rock islets, ledges, low cliffs, beaches, few barriers, tidal flats & marsh	Mud to boulder, abundance low to locally high

*There is no video coverage of the upper part of Musquodoboit Harbour and Jeddore Harbour.

Conventional ground surveying technology has recently been supplemented with the Airborne Laser Terrain Mapper (ALTM), an airborne sensor that uses laser technology to collect thousands of spot elevations per second as an aircraft flies over a land surface. This sensor, combined with two Global Positioning System (GPS) receivers and corrections eliminating aircraft motion, determines the positions of points on the Earth's surface at very high speed and with accuracy (resolution) better than 1 m (GSCA 2002a).

The primary purpose of collecting these data (termed LIDAR for **LI**ght **D**etection **A**nd **R**anging) is to produce high-resolution digital elevation models that can be used to visualize and model the terrain. Specific applications can include identifying the extent of areas susceptible to flooding, or quantifying coastal retreat rates and areas of deposition upon repeat surveys.

LIDAR was recently applied to Chezzetcook Inlet as the first Nova Scotia test case for the measurement of specific coastal features and to establish a baseline data set for measuring future changes within the entire estuary (Figure 4-2). Several natural and anthropogenic changes occurring throughout this estuary, such as rapid erosion of outer coastal features, sediment deposition within the inner inlet, increased pollution and residential development, make Chezzetcook Inlet an ideal test location (GSCA 2002a).

Colour shaded relief images (Figure 4-3; red = highest elevation, blue = lowest elevation) show detailed ground elevations and depict natural features such as forest cover, drumlins (hills), barrier beaches, spits, intertidal flats and channels. ALTM does not penetrate water, and areas of white denote not recorded data. Changing water levels makes it easy to visualize the decreased protection provided by the outer shores to the inner estuary, especially during high water storm events. The distribution and change in position of spits indicates areas of sediment deposition and the direction of its transport (GSCA 2002a).

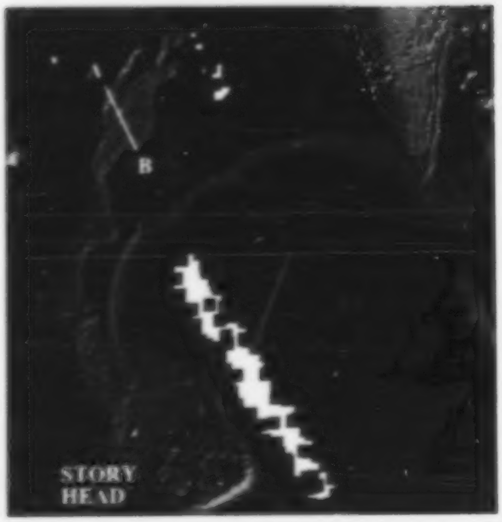
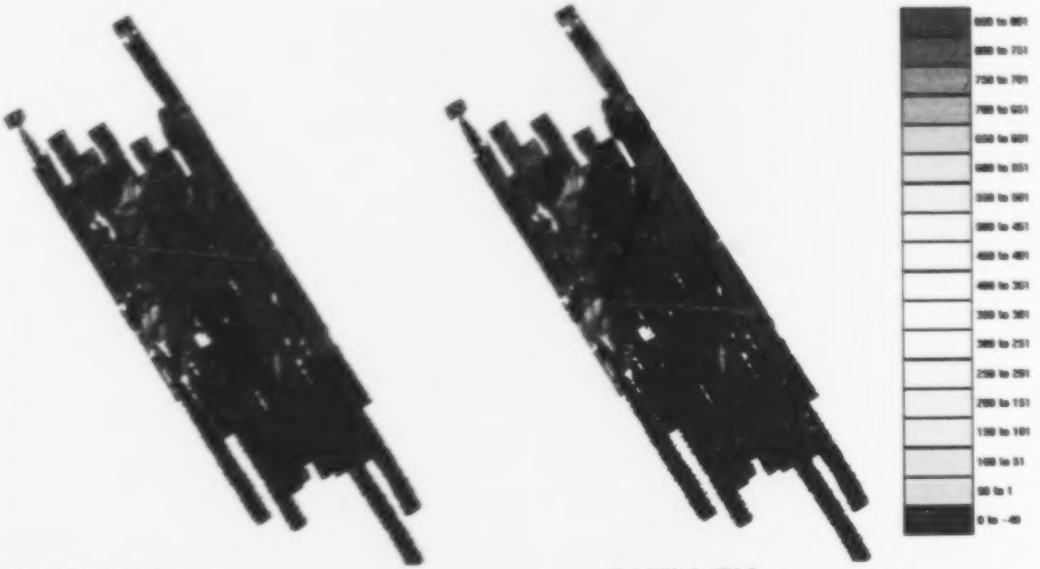


Figure 4-2: LiDAR image of Story Head, Chezzetcook Inlet (GSCA no date)



(a) Mean Tide

(b) High Tide

Figure 4-3: Chezzetcook Inlet at (a) mean tide and (b) high tide, with indexed colour bar for decimetres (GSCA no date)

The prospects for applying LIDAR are very exciting because it will be possible to obtain profile data anywhere on the ALTM image. Volumetric change could be calculated when successive surveys are available for comparison.

Sea level constantly changes, and evidence of its occurrence has been observed, both as rise and fall, over the past several hundreds and thousands of years (Shaw and Gareau 2002). Sea level rise has been measured around Atlantic Canada and within SHACI Units 4-6 over the past 100 years, and tide gauges have documented the extent of this rise (see Figure 4-4).

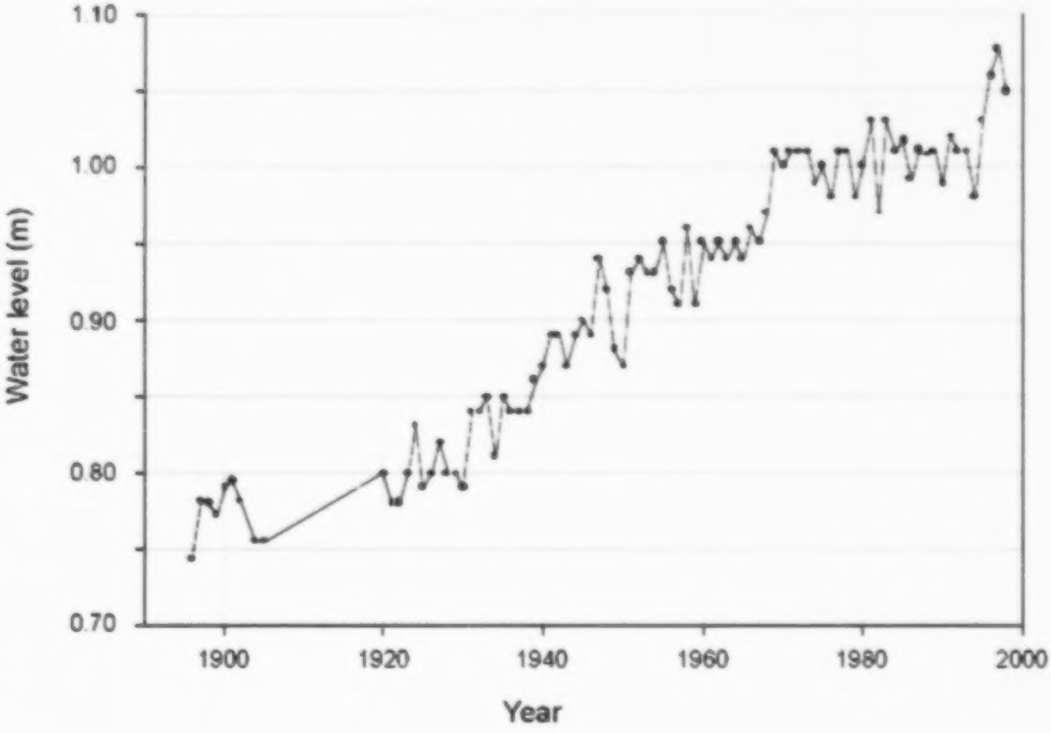


Figure 4-4: Annual mean sea levels at Halifax tide gauge 1895-1998 (GSCA 2002b)

Human activities have accelerated the rate of climate change in recent decades, and sea level rise is among the predicted effects of higher global mean temperatures. The GSCA has classified the Nova Scotian coastline according to an index that measures the likelihood that physical changes will result due to sea level rise. The sensitivity index was sorted into three categories: less than 5 (low sensitivity), 5-15 (moderate sensitivity), and greater than 15 (high sensitivity) (Shaw et al. 1998). Almost all coastlines falling within SHACI Units 4-6 is ranked above sensitivity index value 5, classified as moderate to high sensitivity to sea level rise (see Table 4-4).

Finally, the GSCA is nearly finished the development of a coastal information management system (CIS) for the Atlantic Provinces of Canada. This system will fulfil three primary functions: 1) to effectively store coastal geomorphologic and textural data in a geographic information system; 2) to facilitate user-specific queries and data analysis; and 3) to integrate these coastal data with other applications to enhance coastal zone interpretations and coastal mapping.

The CIS will be able to support several applications, including the robust mapping of coastal features, and investigation of the relationship between coastal features. It can also produce statistics on coastal features per length of coast, such as nearshore form (beach) and material analysis (sand and gravel). These data will be integrated with interpretations of nearshore surficial geology, suggesting linkages between onshore and offshore geology. GSCA staff indicate that the CIS will be accessible to the public and queryable in the near future (Manson pers. comm. 2003).

Table 4-4: Sea level rise sensitivity variables for the Halifax Regional Municipality (HRM) coast from Southwest to Northeast Geological Survey of Canada Atlantic (GSCA no date)

Variables	Chester (incl. Blandford)	Halifax	West Chezzetcook	Musquodoboit Harbour	Owls Head	Tangier	Ecum Secum incl. Liscomb
Average relief (m)	63.0	37.0	10.0	>30	5.0	46.0	19.0
Rock type	Unknown	Granite	unconsolidated	unconsolidated	Metamorphic	Unconsolidated	Unconsolidated
Landform	Drumlin, rock, pocket beach	Till over rock, low rock	Barrier, estuary	upper estuary marsh, till over rock	Sand beach, low rock, bluff	Till over rock, pocket beach, bluff	Rocky islet, till over rock, gravel barrier
Sea level change (cm/100 years)	40.0	37.0	36.0	36.0	37.0	37.0	38.0
Tidal range (m)	2.20	2.10	1.90	2.0	2.00	2.00	2.00
One year maximum wave height (m)	4	7	7.5	7	7.7	7.5	7.5
Sensitivity index	7.90	5.90	42.80	26.20	32.10	14.30	24.80

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5 - Chemical oceanography

Chemical oceanography deals primarily with the composition and reactivity of chemicals in seawater, sediments and biota in the ocean, and how these elements and compounds are affected by physical mixing processes and by interactions with the atmosphere and the sediments and rocks on the sea floor. The distribution of many elements and compounds is determined primarily by physical and biological processes in the ocean and, to some extent, human activities.

Chemical oceanography has a broad scope and the Atlantic coast of Nova Scotia provides many natural laboratories in which to study chemical reactivity in the ocean. For example, studies of primary productivity and nutrient measurements have been undertaken in several areas within Halifax Regional Municipality (HRM): Bedford Basin (e.g., Platt and Irwin 1971, Platt et al. 1973, Taguchi et al. 1975, Irwin and Platt 1978a and b, Irwin et al. 1983, Cote and Platt 1984), St. Margarets Bay (e.g., Platt and Irwin 1968, Platt and Irwin 1972a, Therriault et al. 1978) and Petpeswick (e.g., Platt and Irwin 1972b).

The study of nutrients and primary productivity in Bedford Basin is a major activity. Up to date results are available on the Ocean Science Division website (http://www.mar.dfo-mpo.gc.ca/science/ocean/BedfordBasin/index.htm). Bedford Basin has been used as a study site for numerous other projects devoted to developing an understanding of chemical processes in the ocean. One example is the importance of colloids and colloidal organic carbon in the sequestering and transport of chemical contaminants (Kepkay et al. 1993, Niven et al. 1995 &1997, Moran et al. 1996).

Contaminants and the processes that control their distribution, fate and biological effects are an important component of chemical oceanography. Various land-based sources can contribute to chemical contamination of the ocean. Information on chemical contaminants in the marine environment provides a basis for assessment of marine environmental quality or marine ecosystem health. In this section, contamination of the marine environment in HRM, and more specifically in water, sediments and biota, is addressed. The focus is on nutrients, in terms of eutrophication, and chemical contaminants in the form of heavy metals and organic chemicals, including polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). This section will review literature regarding contamination of water, sediments and biota in HRM and attempt to provide an overview of contamination in SHACI Units 4-6.

Nutrients

Nutrients play an important role in primary biological production. Nitrate, phosphate and silicate are the primary nutrient salts in the ocean (Spencer 1975). In temperate coastal waters, nutrients are found at the lowest levels in surface waters during the summer months following a period of rapid plankton growth (Spencer 1975). As plant and animal debris falls from surface water, it disintegrates and redissolves, releasing nutrients as it settles. This process results in increased nutrient concentrations in subsurface water where there are few plants to consume them.

Whereas a deficiency of these nutrients may limit or stop the growth of primary-producing organisms (Lucas and Critch 1974), excessive levels of nutrients can have significant impacts on ecosystem health by causing noxious or toxic algal blooms, anoxic bottom waters and by killing fish (Table 5-1) (Nixon 1990, Schramm and Nienhuis 1996). Although nutrients occur naturally in water, soil and air, they can also enter the marine environment from various anthropogenic sources. Rivers typically contain higher nutrient levels than surface ocean waters and are thus an important source of nutrients to coastal waters (Yeats 1988). Coastal waters which receive influxes from sewage treatment plants, industries, vehicle exhaust, acid rain, and runoff from agricultural, residential and urban areas, are particularly susceptible to eutrophication which has become a global problem (Nixon 1990, Schramm and Nienhuis 1996).

Table 5-1: Specific changes and secondary effects typically associated with increasing eutrophication* (compiled from Schramm and Neinhuis 1996)

Specific changes	Secondary effects
• Increasing nutrient levels • Occurrence of phytoplankton blooms • Decline or disappearance of certain perennial plant communities, often replaced by annual, fast growing forms (e.g., folious green algae or filamentous algae) • Reduced diversity of flora and associated fauna • Mass development (blooms) of short-lived annual forms which may become "nuisance algae", owing to the fact that they hinder fishing activities and navigation or pollute amenity beaches when cast ashore • Changing depth distribution of benthic algae owing to the reduced light transmittance through the water column	• Increased plant biomass production necessarily leads to enrichment of the pool of particulate and dissolved organic material both in seawater and sediments • Increasing numbers of benthic filter-feeders and detritus-feeders • Enhancement of heterotrophic oxygen-consuming processes which leaf\d to oxygen depletion and finally hydrogen sulphide development • Mass mortalities of plants and animals, in particular in the benthic system • Decline in zooplankton diversity and fish species

*Eutrophication is defined as "the process of natural or man-made enrichment with inorganic nutrient elements" (Schramm and Nienhuis 1996).

Although some coastal areas in Nova Scotia may have increased levels of nutrients and subsequently increased primary productivity, there are few incidences wherein eutrophication has led to the problems listed in Table 5-1. Despite this, there is growing concern in some coastal communities of the potential effects of sewage on nutrient levels. In addition, many of the causative organisms of toxic phytoplankton blooms occur on the Scotian Shelf (Table 5-2). Extensive time series of nutrient data have been collected for the four sites in Table 5-2 (Keizer et al. 1996a and b, Strain 2002) as well as for Sambro (Keizer et al. 1996b) and Bedford Basin (aforementioned studies by Platt et al. and the Ocean Science Division) in Halifax Harbour.

Strain and Yeats (1999) evaluated measurements of nutrients, dissolved oxygen and trace metals in bottom waters of inlets in Nova Scotia as indicators of eutrophication. An eutrophication index (EI) was used to rank the sites according to their eutrophication status. Of the thirteen sites sampled within HRM, Petpeswick Inlet had the highest EI which is attributed to its restricted connections to open water (Table 5-3). Mosher River, the least eutrophic site, has no barriers between the inlet and open water, and is sparsely populated.

Table 5-2: List of potentially toxic or harmful phytoplankton species detected at monitoring stations on the Atlantic coast of Nova Scotia (adapted from Bugden et al. 1992)

Location	Species
Woods Harbour	*Alexandrium* spp., *Dinophysis* spp., *Prorocentrum* spp., *Nitzschia pungens* forma *multiseries*[1]
St. Margarets Bay	*Alexandrium* spp., *Dinophysis* spp., *Prorocentrum* spp., *Nitzschia pungens* forma *multiseries*[1], *Nitzschia pseudodelicatissima*[2], *Chaetoceros concavicornis*
Ship Harbour	*Dinophysis* spp., *Prorocentrum* spp., *Nitzschia pungens* forma *multiseries*[1], *Nitzschia pseudodelicatissima*[2]
Tor Bay	*Dinophysis* spp., *Prorocentrum* spp., *Nitzschia pungens* forma *multiseries*[1], *Nitzschia pseudodelicatissima*[2]

[1] Present name is *Pseudonitzschia mulitseries* (Bates pers. comm. as cited in Stewart and White 2001).

[2] Present name is *Pseudonitzschia delicatissima* (Bates pers. comm. as cited in Stewart and White 2001).

Table 5-3: Eutrophication index for sites in HRM (Strain and Yeats 1999)

Site	Unit	Eutrophication Index
Petpeswick Inlet	5	8.74
Ship Harbour	6	5.87
Jeddore Harbour	5	4.30
Bedford Basin	5	2.57
Sheet Harbour	6	2.25
Popes Harbour	6	2.23
Bedford Bay	5	0.13
Liscomb Harbour	6	-1.14
Chezzetcook Inlet	5	-2.35
Beaver Harbour	6	-3.45
Halifax Harbour-Northwest Arm	5	-3.45
St. Margarets Bay	4	-4.37
Mosher River	6	-5.30

Metals

Metals are key elements of the natural chemical spectrum in the ocean, and are also one of the main groups released by anthropogenic activities (Stewart and White 2001). Metals released into the ocean from natural and anthropogenic sources become dissolved or particulate metals in seawater, attach to suspended particles and are deposited on the seabed as the particles settle, or accumulate in biological organisms.

Many factors influence the concentration of dissolved and suspended metals in seawater and sediments (Stewart and White 2001):

- specific chemistry of the metal;
- interactions with living and non-living material;
- water masses and mixing processes;
- locations and amounts of inputs; and
- exchange processes with sediments and atmosphere.

Measuring metals in the marine environment is important because some are potentially toxic to biological organisms (Stewart and White 2001). Although metals such as copper (Cu), zinc (Zn) and iron (Fe) are essential in low concentrations to normal functioning of biological organisms, they are harmful at high concentrations. Certain metals that do not serve a biological purpose, such as mercury (Hg), lead (Pb) and cadmium (Cd), can be harmful at low concentrations (Ray and Bewers 1984). In general, metals can damage biological organisms by impairing enzyme function and ion exchange processes which, in extreme cases, can affect all physiological processes of an exposed organism (Stewart and White 2001).

The Canadian Council of Ministers of the Environment (CCME) developed water quality guidelines for the protection of aquatic life (CCME 2002a). Guidelines for metals are listed in Table 5-4. These guidelines provide a standard with which to evaluate elevated dissolved metal levels. However, for the majority of parameters listed by the CCME, there are no guidelines for concentrations in the marine environment.

Table 5-4: Canadian water quality guidelines for the protection of aquatic life (adapted from CCME 2002a)

Parameter	Guideline (g/L)	
	Freshwater	Marine
Ammonia (un-ionized)	19	
Arsenic	5	12.5
Chromium		
Trivalent	8.9	56
Hexavalent	1.0	1.5
Cadmium	0.017	0.12
Copper	2-4	-
Iron	300	-
Lead	1-7	-
Mercury	0.1	-
Nickel	25-150	-
Zinc	30	-
Nickel	25-150	-
Silver	0.1	-
Aluminium	5-100	-

- denotes no guideline

The CCME also developed Canadian sediment quality guidelines for the protection of aquatic life. The recommended chemical concentrations aim to support and maintain aquatic life associated with sediments (CCME 1999). The guidelines include threshold effects level (TEL), the level below which adverse biological effects are expected to occur rarely, and probable effects level (PEL) which refers to the level above which adverse effects are expected to occur frequently (Table 5-5) (CCME 1999). Using TELS and PELs, three ranges of chemical concentrations are typically defined: "1) the minimal effect range within which adverse effects rarely occur (i.e., fewer than 25% adverse effects occur below the TEL); 2) the possible effect range within which adverse effects occasionally occur (i.e., the range between the TEL and PEL); and, 3) the probable effect range within which adverse biological effects frequently occur (i.e., more than 50% adverse effects above the PEL)" (CCME 1999). Incidences of adverse biological effects in the concentration ranges defined by the TELs and PELs are also provided in Table 5-5. These guidelines can be used to assess the degree of sediment contamination and to evaluate the potential for observing adverse biological effects in aquatic systems.

Table 5-5: Threshold effects levels (TEL; dry weight), probable effects levels (PELs; dry weight) and incidence (%) of adverse biological effects in concentration ranges by these values (CCME 2002b).

Parameter	TEL (mg/kg)	PEL (mg/kg)	%=TEL	TEL<%<PEL	%=PEL
As	7.24	41.6	3	13	47
Cd	0.7	4.2	6	20	71
Cr	52.3	160	4	15	53
Cu	18.7	108	9	22	56
Pb	30.2	112	6	26	58
Hg	0.13	0.70	8	24	37
Zn	124	271	4	27	65
PAHs	0.77	7.07	-	-	-
PCBs	0.022	0.189	16	37	55

Synthetic organic chemicals and hydrocarbons

Organic chemicals are chemical compounds that have carbon in their molecular structure. They are generally only slightly soluble in water and have a high affinity for suspended particulate material (Stewart and White 2001). In biological organisms, they are more likely to occur in the fatty tissues or lipids. Thus significant concentrations can be found in biota compared to other environmental components.

Organochlorines include many of the common pesticides, such as DDT and its breakdown products DDE and DDD, and PCBs (Stewart and White 2001). Organochlorines commonly found in the marine environment include DDT and its derivatives, and industrial compounds such as PCBs. The presence of organochlorines in the marine environment is of concern because these compounds degrade slowly and concentrate in animal tissues, leading to biomagnification.

Hydrocarbons and PAHs are also contaminants found in the marine environment. Hydrocarbons are ubiquitous contaminants of the marine environment occurring naturally (e.g., released from seeps and, to a lesser extent, produced by marine plants and zooplankton) (Gordon et al. 1978), or via vessel traffic, fuel and lubricant spills, blowouts or tanker accidents (Stewart and White 2001). PAHs are present in crude oil and processed hydrocarbons, and can enter the marine environment when these substances are deposited there (Stewart and White 2001). PAHs can also be released into the ocean as byproducts of fossil fuel or wood combustion and by creosote from treated timbers used in constructing wharves (Eaton and Zitko 1978, Wells and Rolston 1991). All PAHS are toxic to some degree, and several are carcinogenic to animals, including fish and mammals (Wells and Rolston 1991).

Tributyltin (TBT), an anti-fouling organotin compound used in ship paints and fishing gear treatments, is highly toxic to marine organisms (Maguire et al. 1986). Tributyltin concentrations in the range of 0.04-16 g Sn/L are lethal to copepods, mussel larvae, crab larvae, lobster larvae, sheepshead minnow, bleak, guppy and rainbow trout (Maguire et al. 1986). Ten percent of 221 locations across Canada had tributyltin concentrations in water high enough to be of concern with regard to chronic toxicity or effects on sensitive organisms, and are typically those that have heavy shipping or boating traffic (Maguire et al. 1986). The Canadian water quality guidelines for the protection of aquatic life suggest 0.001 g/L as the guideline for TBT.

Polycyclic and nitro musks, commonly used as fragrance ingredients in soaps, cosmetics and laundry detergents (Gatermann et al. 1999), have been found in marine and freshwater environments (Gatermann et al. 1995, Rimkus and Wolf 1995) and in fish, mussels, shrimps (Eschke et al. 1994 as cited in Gatermann et al. 1995, Rimkus and Wolf 1995), human adipose tissue and breast milk (Liebl and Ehrenstorfer 1993, Rimkus et al. 1994, Müller et al. 1996). The reduction of the nitro group to the corresponding amine, which is generally more toxic, is one of the major pathways of biological transformation of nitroaromatic compounds (Gatermann et al. 1999). Thus the presence of nitro musks and their metabolites in the environment is of concern.

Numerous other manmade organic compounds that could have negative impacts on the environment are being investigated. These include manylphenol ethoxylates, a group of compounds used as detergents and emulsifiers that are discharged into sewage systems; brominated diphenyl ethers that are used as fire retardants; pharmaceuticals and other potentially endocrine disrupting substances, as well as approximately 50 groups of compounds on the Environment Canada Priority Substances List.

Sources of contaminants

Contaminants may enter the ocean through natural processes such as weathering of the continents, coastal rock and seabed, or anthropogenic processes (Stewart and White 2001). These substances enter the ocean in surface runoff, suspended in the air as dust, dissolved in groundwater, released from the sediments following a physical, chemical or biological alteration of sediments or from a direct deposit such as a spill.

Various processes determine the chemistry of the ocean and its sediments, including the long-term weathering of the continents; the redistribution and modification of the dissolved and particulate material by physical, chemical and biological processes; and the continuous interaction of the sea with the atmosphere, coastal and offshore rock, sands, mud and biota (Stewart and White 2001). The concentration and distribution of chemicals are influenced by biological organisms. Waters capture and dissolve gaseous and particulate contaminants from the atmosphere and leach materials from the sediments. The types of seabed material available can influence sediment transfer, thus affecting water chemistry.

These naturally-occurring processes can occasionally cause above-normal levels of chemicals. For example, chemical interactions with sediments in deep basins on the Scotian Shelf cause elevated levels of manganese (Mn) in suspended matter above the basins (Stewart and White 2001). When considering contaminants, it is therefore important to be aware of their source and natural abundance. For example, metals and nutrients occur naturally and thus the relative amounts of these parameters must be interpreted in the context of natural abundances. Synthetic organics such as tributyltin and PCBs are exceptions since they do not occur naturally.

In coastal areas, where the majority of the population resides and industrial development occurs, chemicals can enter the marine environment directly through various anthropogenic sources (Stewart and White 2001). Coastal areas on the Scotian Shelf have been exposed to various sources of contaminants, such as urban and industrial effluents (Table 5-6). The fishing industry and associated infrastructure (e.g., wharves, fish processing operations, and vessel maintenance and repair facilities) is a source of organic contamination (e.g., fish plant wastes), hydrocarbon releases from fuels and lubricants, and anti-fouling and wood preservative chemicals such as tributyltin, but does not contribute significantly to contaminant levels on the Scotian Shelf (Stewart and White 2001).

Table 5-6: Pollution sources in coastal and offshore areas of the Atlantic coast of Nova Scotia (Stewart and White 2001)

Source	Nature of contaminant/Impact
Municipal effluents	Shellfish and aquaculture closure due to bacterial contamination Enrichment of sediment organic content near outfalls and seepages Contamination of sediments and waters by metals and organic chemicals (e.g., PCBS and hydrocarbons) Nutrient enrichment of coastal waters
Dredging and ocean dumping	Contaminants occurring at concentrations below Ocean Dumping limits in sediments, including PAHs, PCBs, trace metals, organic matter, oil and grease
Wharves and coastal structures and associated activities	Metals and organic compounds in paints; creosote and preservatives (e.g., Wolmanized lumber, chromated copper arsenate) on wharf pilings
Aquaculture (fish and shellfish farming)	Organic matter, trace metal enrichment
Industrial Effluents	
Pulp and paper	Wood fibre, suspended solids, effluents having high biological oxygen demand (BOD) and contaminants (e.g., dioxins and furans)
Food processing (including fish processing)	Effluents high in BOD, suspended solids, oil and grease, bacteria and organic and inorganic contaminants
Petroleum refining	Oil and grease, sulphide, ammonia, phenol, suspended solids, and PAHs
Smelters and steel industry	PAHs and other organic chemicals; metals
Thermal generating plants	PAHs from coal ash and leachates (including coal tar and creosote). PAHs and metals from atmospheric deposition
Shipyards and vessel maintenance	Organics, metals, antifouling chemicals (e.g., tributyltin, lead)
Mining and associated industries	Acid mine drainage, metals, organics, waste rock, arsenic from gold tailings
Hydrocarbon storage, shipment and distribution	Hydrocarbons account for most of accidental spillages of chemicals in Atlantic Canada

Coastal areas receive contaminants in river flow and from various non-point sources of pollution, including agriculture and forest sprays, atmospheric deposition, and urban runoff, which contain hydrocarbons, metals, silts and persistent plastics that enter waters near cities and industrial sites (Stewart and White 2001). The highly forested coastal areas and watersheds of Nova Scotia limit chemical releases associated with agriculture, and are not considered important compared to areas where agriculture is more prevalent. Significant loads of organic contaminants have been added to the marine environment via release of contaminants from combustion of fuels, particularly in heavy industry and thermal power generation. The Scotian Shelf receives a wide range of contaminants via atmospheric transport from more industrialized areas of eastern North America (Stewart and White 2001).

Activities in coastal waters, such as bottom trawling in commercial fisheries, seabed mining and construction of coastal facilities, can redistribute contaminants (Stewart and White 2001). Trawling increases suspended sediment levels above the bottom and mixes surface and subsurface sediment layers (Mayer et al. 1991). Mining the seabed for sand or extraction of minerals can lead to elevations in suspended particulate material in the water column, potentially causing the release of contaminants from the sediments (Stewart and White 2001).

Pollutants released by different sources can vary in composition and abundance. For example, copper (Cu) and aluminium (Al) concentrations in landfill leachate released into Sackville River are lower than those in effluents from municipal wastewater treatment plants (MWTP) in the province (Table 5-7). Chambers et al. (1997) report 142 organic chemicals detected in MWTP effluents but note that concentrations of chemicals in effluents resulting from similar treatment processes can vary considerably depending on domestic versus industrial volume, types of industries, surface area served and volume treated (Table 5-7). In HRM there are twelve sewage treatment plants and one landfill leachate facility (HRM 2002).

Table 5-7: Concentrations of various parameters from municipal wastewater treatment plant effluents and landfill leachate in Nova Scotia (adapted from Chambers et al. 1997)

Output source	Biochemical oxygen demand (mg/L)	Total suspended solids	Ammonium (mg/L)	Aluminium (g/L)	Copper (g/L)	TRC (g/L)
2 secondary MWTPs[1]	<5-50	25-45	<0.14-28	280- 12 000	20-120	5-850
Eastern Passage primary MWTP[1]	80	31	18	320	20	250
Lakeside tertiary MWTP[1]	<5	12	2.0	340	30	120
Landfill leachate from swamp outflow to Sackville River[2]	120	580		170	< 10	

[1] Rutherford et al. 1994

[2] Ernst et al. 1994

Prouse (1994) examined harbours in the Maritimes provinces with a surrounding population of 500 or greater and ranked them for potential to contaminate American lobster with PAHs. Five criteria were used for evaluating potential PAH input to each harbour: point sources, surrounding human population, industrial and commercial activity, international and domestic ship traffic, and the number of commercial fishing vessels. Of 14 harbours examined, Halifax Harbour was ranked the second most likely to yield lobsters contaminated with PAH, second only to Sydney Harbour.

Halifax Harbour, its approaches and tributaries

Water

A study of dissolved metal concentrations from various locations in Halifax Harbour indicated that dissolved metal concentrations are relatively low, but are higher than those on the Scotian Shelf which are considered to be at background levels (Table 5-8) (Dalziel et al. 1991). In general, metal concentrations were roughly twice those found on the Scotian Shelf. However, average Zn, Mn and Fe concentrations were four to five times higher than those on the Scotian Shelf (Dalziel et al. 1991). Relative to other waters, these elevated metal levels indicate significant contamination (Stewart and White 2001), despite being below guidelines for protection of marine aquatic life (McNeely et al. 1979).

Table 5-8: Dissolved metal concentrations in Halifax Harbour (Dalziel et al. 1991)

Metal	Concentration (g/L)	
	Halifax Harbour	Scotian Shelf
Cadmium (Cd)	0.014-0.072	0.025
Copper (Cu)	0.17-0.91	0.25
Iron (Fe)	1.0-6.7	0.50
Manganese (Mn)	0.44-23.5	1.00
Nickel (Ni)	0.26-1.14	0.30
Lead (Pb)	0.006-0.286	0.025
Zinc (Zn)	0.7-70	1.00
Mercury (Hg)	trace-0.0025	

Particulate metal data indicate that concentrations of Zn, Cu and Pb from the Harbour were significantly higher than those from the Scotian Shelf, but similar to levels in other coastal estuaries (Dalziel et al. 1991) (Table 5-9). Cadmium and nickel (Ni) concentrations were two to three times higher than average levels for the Scotian Shelf. The high levels of Mn and iron in the deep water of Bedford Basin were attributed to remobilization from anoxic bottom sediments. No appropriate guideline exists with which to evaluate elevated particulate metal levels, however, these concentrations also suggest a significant level of contamination in Halifax Harbour (Stewart and White 2001).

Table 5-9: Particulate metal concentrations in Halifax Harbour (Dalziel et al. 1991)

Metal	Concentration (g/g)			
	Halifax Harbour	Bedford Basin	Ferguson's Cove (Outer Harbour)	Scotian Shelf
Aluminium	21 000	26 000	33 000	-
Cadmium	1.9	1.8	1.8	0.5
Copper	106	135	55	4
Iron	53 200	24 700	20 600	-
Lead	164	288	152	8
Manganese	9 930	8 080	1 620	-
Nickel	46	41	31	30
Zinc	422	525	250	50

Seawater in Bedford Basin contains slightly elevated levels of crude oil equivalents compared to the open ocean and St. Margarets Bay (Table 5-10) (Gordon et al. 1978). The varying concentrations of crude oil equivalents and *n*-Alkanes suggest a seasonal pattern, with the greatest concentrations occurring during the winter. Concentrations of *n*-Alkanes were not significantly greater than those of oceanic waters. Gordon et al. (1978) suggest that most, if not all, of the aromatic hydrocarbons in Bedford Basin seawater are anthropogenic, with the high winter concentrations potentially corresponding to the increased use of fuel oils for heating and thermal electrical generation in Halifax and Dartmouth during the winter.

Table 5-10: Concentration of petroleum hydrocarbons in Bedford Basin (1975-1976) and St. Margarets Bay (1975) (Gordon et al. 1978)

	Hydrocarbon Concentration			
	Bedford Basin		St. Margarets Bay	
	2 metres	50 metres	2 metres	50 metres
Crude oil equivalents (g/L)	2.5	1.8	0.5-0.7	0.2-0.7
Total n-alkanes (ng/L)	220	180	52-240	206-1 100

Levels of tributyltin in water samples from Halifax Harbour were below the limit of detection and those in sediment were below the limit of quantification (Maguire et al. 1986).

Hellou et al. (2005) investigated the partitioning of parental (par) and alkylated (alk) PAHs between the soluble and particulate phases in the inter-tidal zone of Halifax Harbour. Overall, dissolved alkPAH concentrations were higher in water at the site closer to raw combined municipal sewage effluents than at the other two sites and particles of that site. The study indicated that sewage treatment plants will reduce the amount of parPAH being deposited in the Harbour; that alk naphthalenes and fluorenes present in water will continue to be discharged; and that the disturbance of sediments can make particle-bound PAH available to mussels.

Sediments

Trends of contamination

Since its founding in 1749, Halifax Inlet has been receiving a broad spectrum of contaminants from industrial and domestic activities. Over the past 250 years, patterns of human activities and thus release of contaminants into the Inlet have varied. Patterns of contaminant distribution have been identified using factor analysis and estimates of the date of deposition and contaminant concentrations for layers in the sediments (Table 5-11) (Buckley et al. 1995). The relative influence of each of the key contaminant sources has changed over time and varies depending on the location in the Harbour (Buckley et al. 1995). In most of Bedford Basin, the dominant influence from 1840 to the present has been the sedimentation of material from freshwater runoff, with a brief period (1968-78) dominated by diagenetic processes (Buckley et al. 1995).

Natural diagenetic processes were the dominating force in the central Harbour up to 1900, following which industrial and sewage wastes increased in importance and became the key influence until 1960 (Buckley et al. 1995). Between 1960 and 1972, surface drainage and diagenetic processes dominated once again. Sewage contamination became the dominant influence after 1972, probably as a result of the rapidly expanding population (Buckley et al. 1995).

Table 5-11: Spatial and temporal trends of contamination in Halifax Inlet, 1840 to present (Stewart and White 2001)

Location in Halifax Inlet	Direct sewage contamination (primary contamination)	Contamination from landfill and industry (secondary contamination)	Diagenetic processes[1]	Surface drainage/runoff
Bedford Basin	Minor	Mid-1980s	1968-1978	1840-1970 1978-present
Central Harbour	1900-1960 1972-present	1900-1960	1840-1900 1960-1972	
Northwest Arm	1970-present	1916-1970		1840-1916

[1] biological, physical and chemical processes that alter sediment characteristics over time

Until 1916, sediments in the Northwest Arm were dominated by surface drainage influences (Buckley et al. 1995). Following this, secondary and primary contamination became important factors, the latter coinciding with the placement of a major sewage outfall at the entrance to the Arm. PAH contaminants in sediments suggest a shift in burning practices away from wood and coal in the post-1960 period (Gearing et al. 1991).

Contaminant distributions

Analyses of sediment chemistry have helped to determine key sources of contaminants in Halifax Inlet. Levels of organic carbon, Cu, Pb, Zn and Hg in sediments in Halifax Harbour, the Northwest Arm and Bedford Basin indicate sewage and industrial contamination (Table 5-12) (Buckley and Hargrave 1989). The degree of contamination is greater than observed in other coastal and estuarine sediments in eastern Canada. Compared to uncontaminated coastal marine areas, the mean concentration of these elements are greater by factors of 4.2 for organic carbon, 4.5 for Cu, 3.3 for Zn, 6.4 for Pb, and 2.0 for Hg (Buckley and Hargrave 1989). Zinc, Cu, Pb, Cd and Hg concentrations in sediments are 1.4 to 1.7 times greater, and organic carbon is 1.3 times greater near sewage outfalls than the average for Halifax Inlet as a whole (Buckley and Winters 1992). The highest concentrations of metals were found in fine-grained and organic-rich sediments, such as occur in Bedford Basin, the central Harbour and the Northwest Arm (Buckley and Winters 1992). Anomalously high concentrations of metals (Cu, Zn, Pb and Hg) were found in sediments near major untreated sewage outfalls in the central harbour and the Northwest Arm (Buckley and Winters 1992). Sewage outfalls affect approximately 2.75 km^2 of the Inlet (Buckley and Winters 1992). Elevated concentrations of organic carbon and metals in sediments led to the identification of twelve major contaminated areas in Halifax Harbour, which are associated with major sewer outfalls and suspected industrial contamination (Buckley and Hargrave 1989). Figures 5-1 to 5-6 show sediment concentrations of metals with respect to MEQ thresholds[1] in Halifax Harbour which show that Halifax Harbour has substantive areas with concentrations greater than the PEL for Pb, Cu, Hg, Zn, PCBs and PAHs.

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[1] Background levels were derived using a geochemical normalization technique that accounts for natural variability in grain size and mineralogy using lithium (Li) as the normalizing element as described by Loring (1991) and data from relatively pristine inlets from Nova Scotia from Loring et al. (1996) (Yeats pers. comm. 2005).

Table 5-12: Representative contaminant concentrations from surface sediments in areas within HRM (adapted from Stewart and White 2001)

Contaminant	Concentration (g/g)												
Metal	Halifax Harbour (grab samples)[1]	Halifax Harbour (cores)[2] 1900-present	Tuft's Cove[3]	Central Bedford Basin[4]	Northwest Arm[5]	Sackville River Mouth[6]	Bedford Basin	Dartmouth Cove[6]	Eastern Passage[6]	Three Fathom Harbour[6]	East Chezzetcook[6]	East Jeddore[6]	West Jeddore[6]
Copper	91	88	323	96	109	15-19	15-19	151-223	26.4-38.0	11.6-33	9-30	18.9	8.9
Cadmium	85.2	-	1.4	0.8	-	< 0.02-1.7	< 0.02-1.7	1.51-1.87	0.32-0.38	0.06-0.45	0.009-0.5	0.56	<0.001
Lead	160	206	281	231	231	17-37	17-37	418-590	26.4-35.4	5.2-50	2-10	17.4	2.08
Manganese	663	-	-	-	-	-		-	-				
Mercury	0.92	1.6	12.3	1.3	1.25	0.05-0.07	0.05-0.07	1.52-2.99	0.15-0.27	0.01-<0.2	0.1-0.08	0.08	<0.01
Zinc	226	249	9 582	273	274	41-68	41-68	402-436	75.8-107.6	17.5-74	4-22	74.5	7.78
Organics (g/g)													
PAHs (Total)	-	-	14.4	8.8	20-27	-	-	-	-	-	-	-	-
Aliphatic hydrocarbons	-	-	-	-	1 770	-	-	-	-	-	-	-	-
Chlorinated Organics (ng/g)													
PCBs (Total)	-	-	-	-	-	40-110	40-110	< 1.7	54-92	<0.5-<5	<0.5-6	<0.5	<0.5
DDTs (Total)	-	-	-	-	-	< 5	-	140-410	31-36	<0.3-<1.7	<0.35-<1	<0.35	<0.35

[1] Buckley and Winters (1992)

[2] Buckley et al. (1995)

[3 & 4] Tay et al. (1992), average of two stations

[5] Gearing et al. (1991), maximum values.

[6] OceanChem (1985)

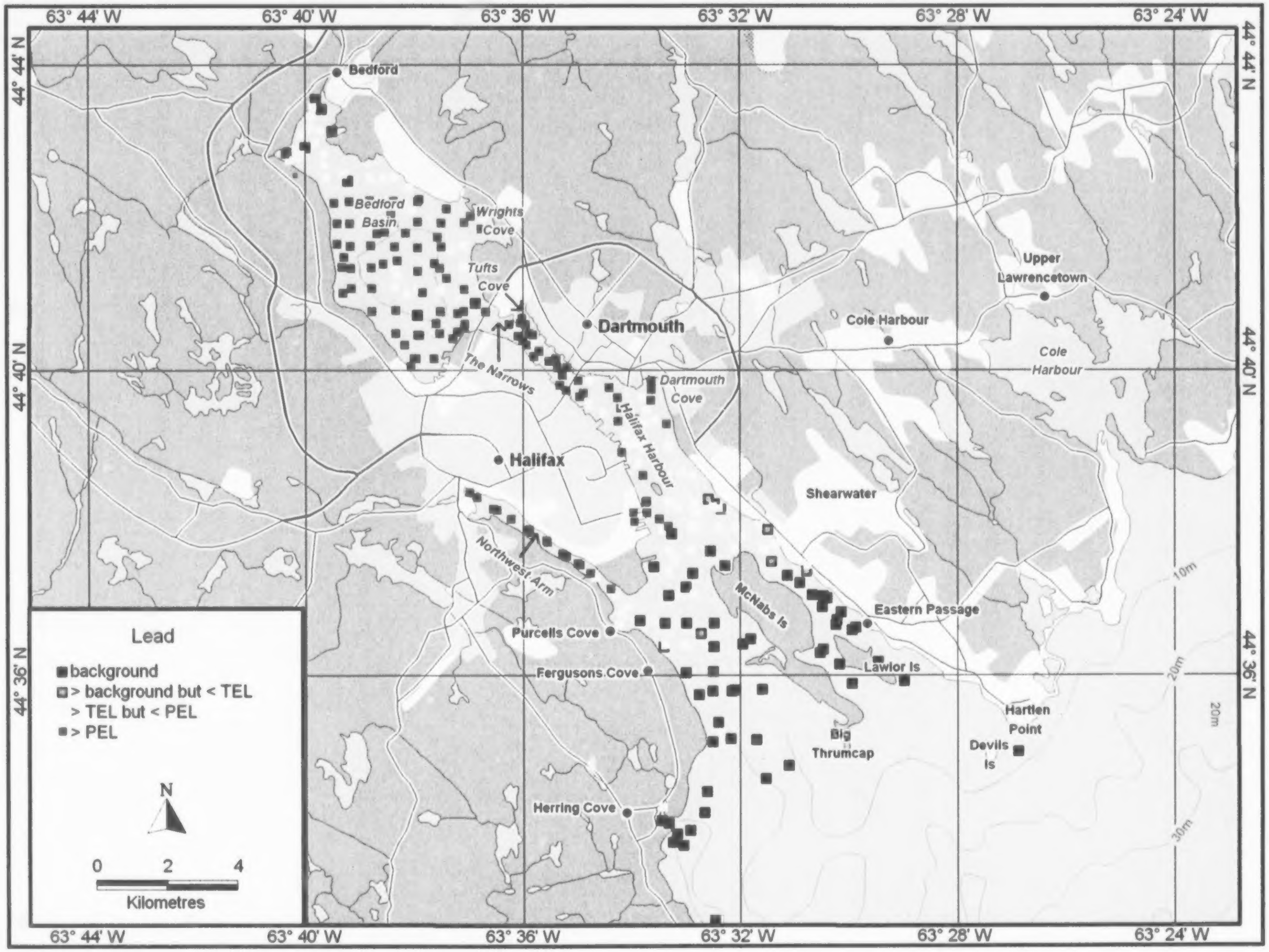

Figure 5-1: Sediment concentrations of lead in Halifax Harbour (based on data from Winters et al. 1991) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

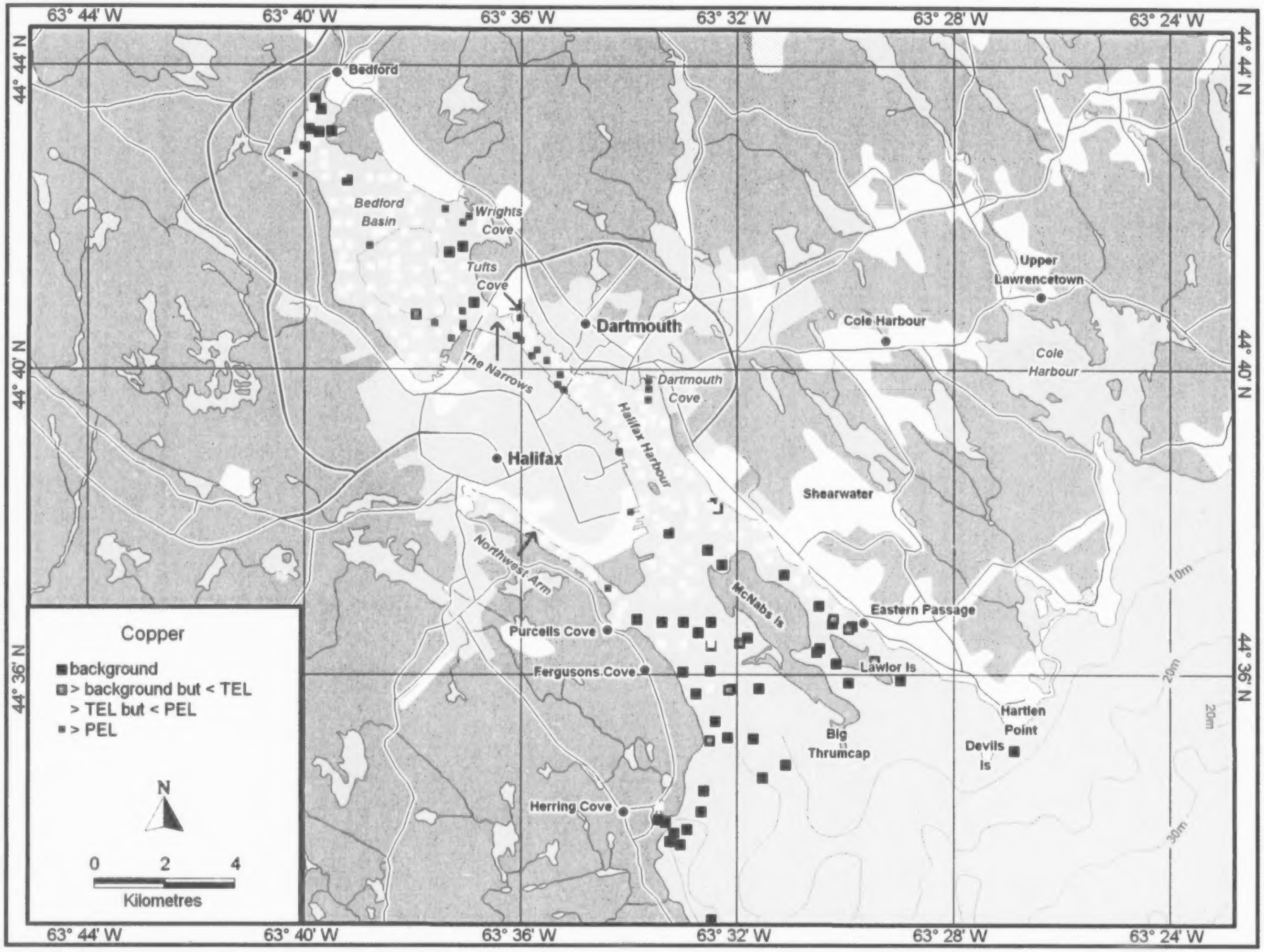

Figure 5-2: Sediment concentrations of copper in Halifax Harbour (based on data from Winters et al. 1991) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

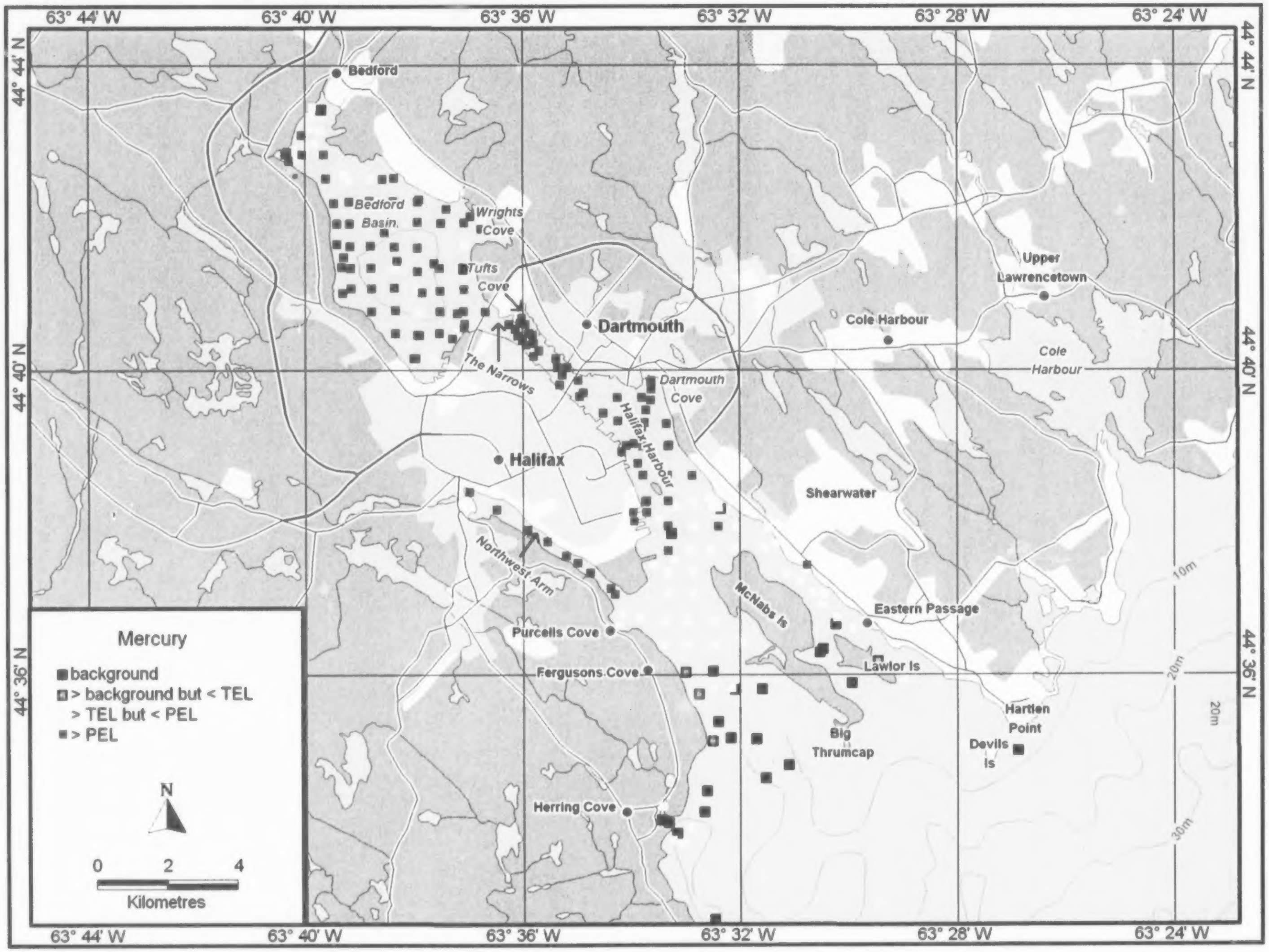

Figure 5-3: Sediment concentrations of mercury in Halifax Harbour (based on data from Winters et al. 1991) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

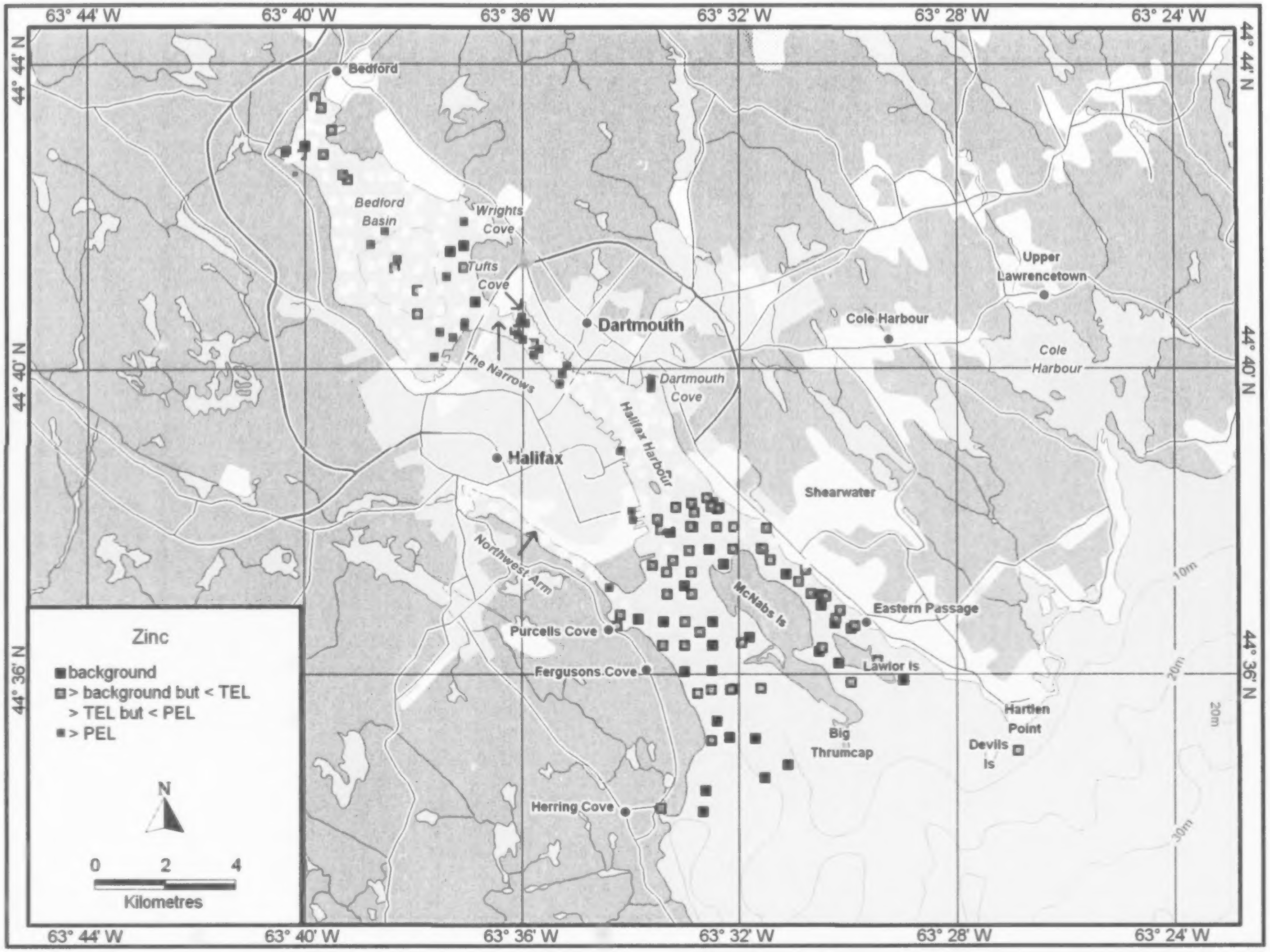

Figure 5-4: Sediment concentrations of zinc in Halifax Harbour (based on data from Winters et al. 1991) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

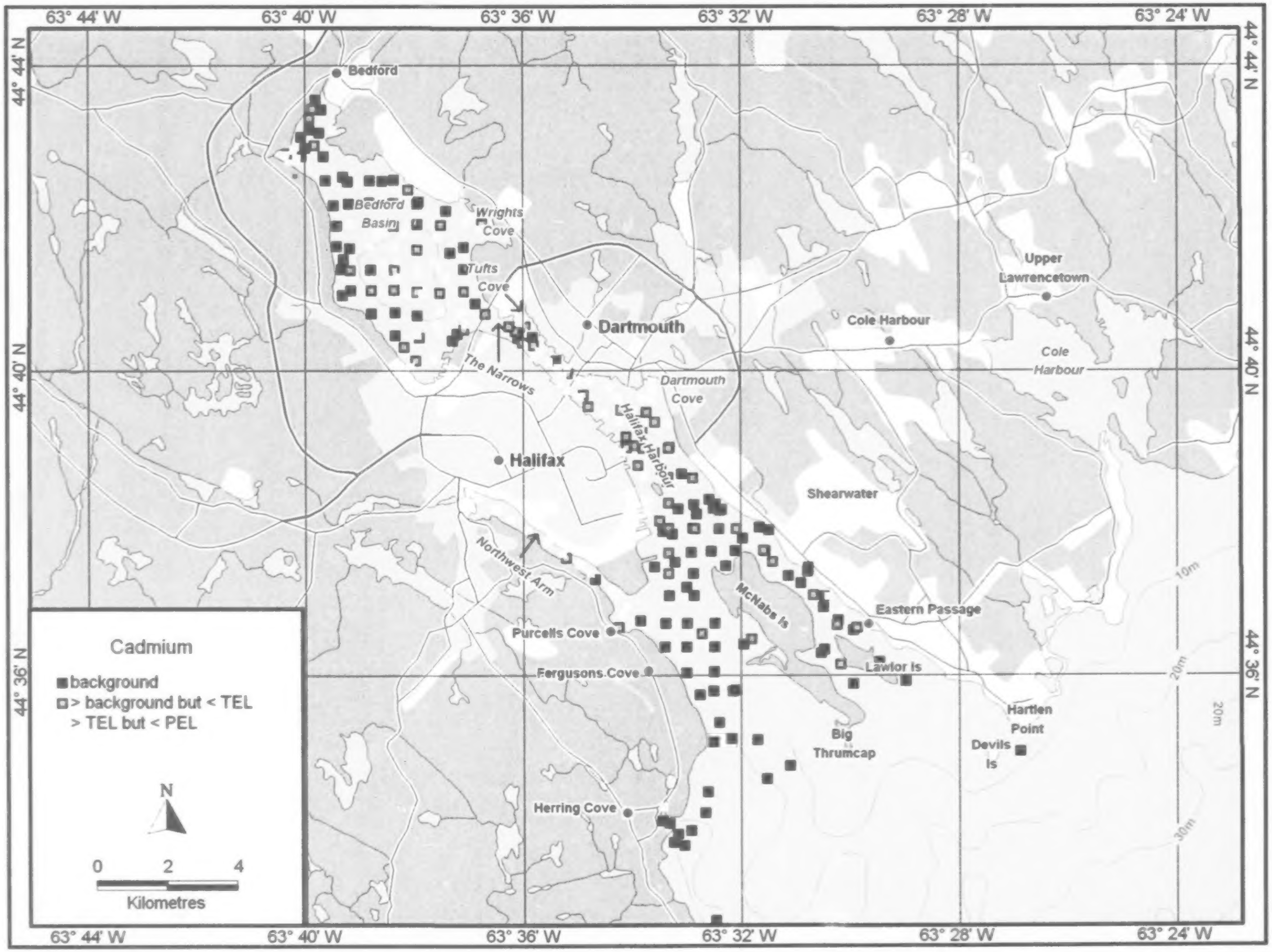

Figure 5-5: Sediment concentrations of cadmium in Halifax Harbour (based on data from Winters et al. 1991) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

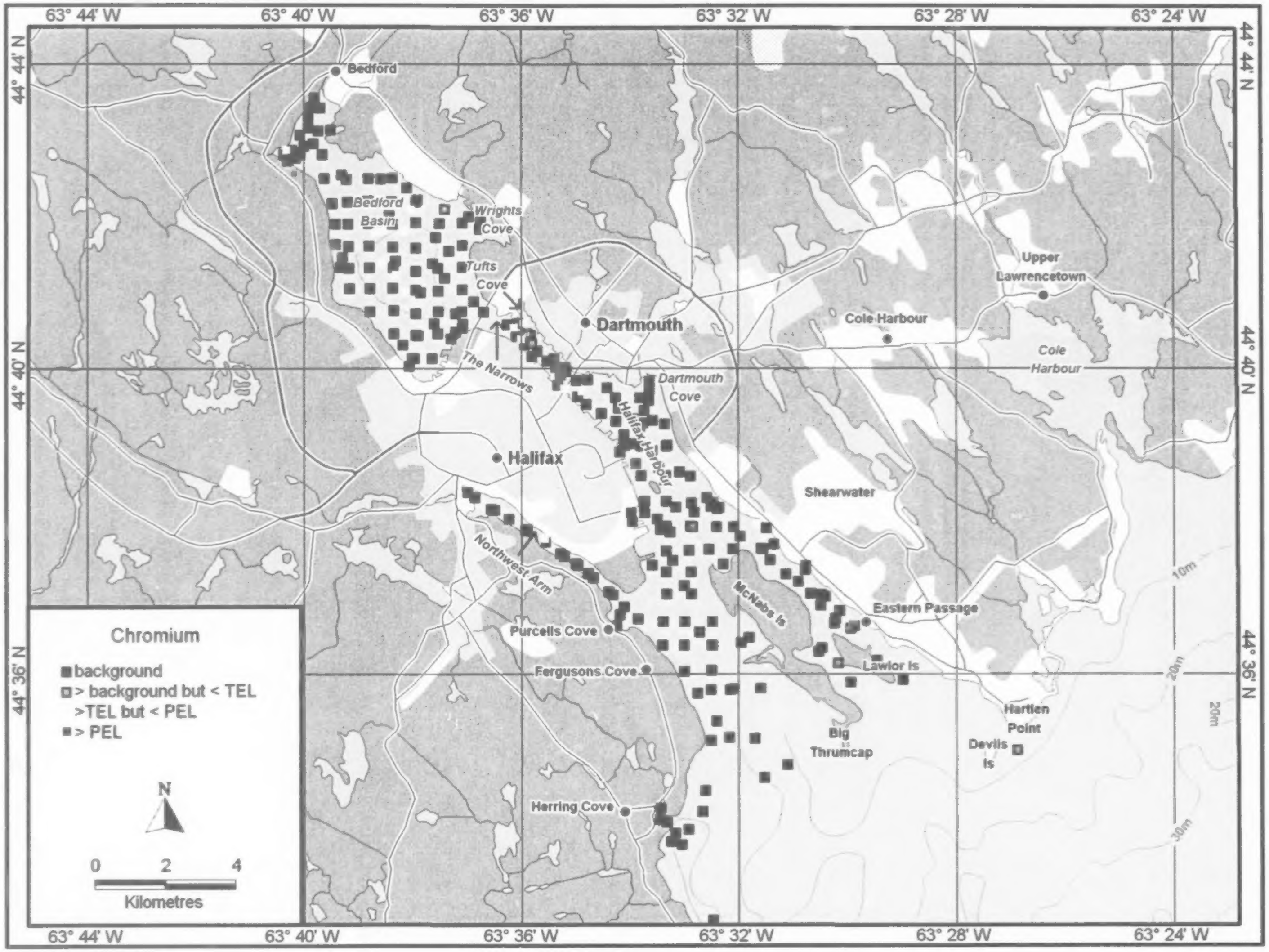

Figure 5-6: Sediment concentrations of chromium in Halifax Harbour (based on data from Winters et al. 1991) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

OceanChem (1985) identified two areas in HRM as problem areas because sediment concentrations of certain contaminants exceeded the maximum allowable limit set by the *Ocean Dumping Control Act*. Dartmouth Cove and Bedford Basin had cadmium levels above the 0.6 g/g limit. Dartmouth Cove also had Hg levels that exceeded the limit (> 0.75 g/g). Levels of DDTs in Eastern Passage and Dartmouth Cove were above background levels measured near wharves on the Eastern Shore (Leonard 1977) and above the TEL (4.48 ng/g for total DDT) (CCME 2002b) (Table 5-12). Concentrations of DDTs found in Dartmouth Cove were above the ocean dumping guideline for pesticides of 100 ng/g (OceanChem 1985).

Of coastal sites sampled in HRM, Eastern Passage and Sheet Harbour had the highest concentrations of PCBs, exceeding background levels (10 ppb) (Leonard 1977). These concentrations of organohalogens are much lower than those reported for highly polluted areas such as the California coast and are in the same range as those reported from other coastal areas (Leonard 1977). OceanChem (1985) found elevated concentrations of PCBs in Eastern Passage and Bedford Basin (Table 5-12). In Eastern Passage, PCB concentrations of up to 800 ng/g were found near refineries and wharves (Travers and Wilson 1977 as cited in Stewart and White 2001), exceeding the PEL of the sediment quality guidelines (CCME 2002b). Other coastal areas were relatively uncontaminated with PCBs.

Hellou et al. (2002a) analyzed surficial sediments around the perimeter of Halifax Harbour for the presence of PCBs. PCB levels were above PEL in many locations. A downtown site close to numerous raw sewage effluents had the highest overall PCB concentrations. The lowest concentrations were observed at the entrance to the Harbour. Figure 5-7 shows the sediment concentrations of PCBs with respect to MEQ thresholds in Halifax Harbour.

Petroleum hydrocarbons and PAHs are the principle organic contaminants of Halifax Inlet sediments (Stewart and White 2001). Average concentrations of petroleum residues in Halifax Harbour sediments are the highest found along the Atlantic coast of Nova Scotia (Stewart and White 2001).

Of 65 locations sampled for petroleum residues in sediments along the shores of New Brunswick, Prince Edward Island and Nova Scotia, only one location in HRM, the Northwest Arm, had average petroleum residues >100 g/g, which is roughly 4.5 times greater than the Atlantic Canada average of 23 g/g (Levy et al. 1988) (Table 5-13). Elevated concentrations of petroleum residues in Northwest Arm sediments were located near mooring facilities and adjacent to a sewage outfall situated in Point Pleasant Park. The high petroleum residue concentrations of Halifax Harbour and its approaches are likely a result of the Harbour being a major port and industrial centre.

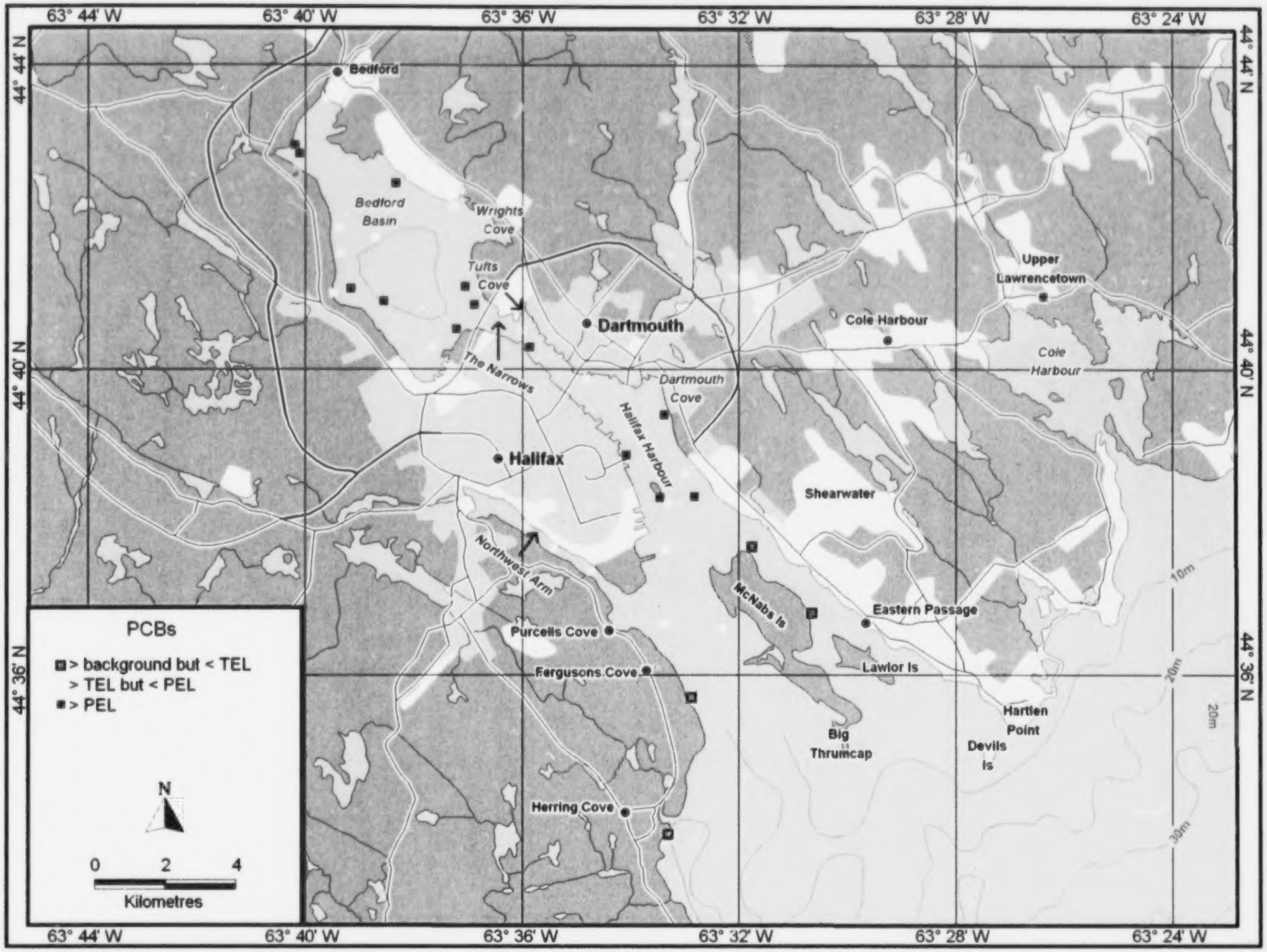

Figure 5-7: Sediment concentrations of PCBs in Halifax Harbour (based on data from Winters et al. 1991) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

Table 5-13: Petroleum residues in sediments from areas in HRM (Levy et al. 1988)

Location	Unit	Petroleum Residue (g/g)	
		Range	Average
Bayswater Beach	4	0.22-0.56	0.39
Northwest Arm	5	10.93-194.6	101.5
Halifax Harbour	5	0.99-376.5	82.17
Bedford Basin	5	1.50-127.6	47.21
Dartmouth	5	3.35-200.00	84.34
Ship Harbour	6	0.24-5.82	1.14
Sheet Harbour	6	0.35-5.04	1.99

Pollutant hydrocarbons in sediments of the Northwest Arm have increased 100-fold since 1900 and levels near the sediment surface are quite high (maximum 1700 g/g dry weight) (Gearing et al. 1991). These levels are well above those found on the Scotian Shelf (1-94 g/g) (Keizer et al. 1978) and in an unpolluted Bay in Newfoundland (1-5 g/g) (Keizer 1974). Levels greater than 500 g/g are thought to cause ecological damage and a concentration of 10 g/g is considered an unacceptable level for ocean dumping (Olsen et al. 1982 as cited in Gearing et al. 1991).

Recent concentrations of PAHs in the top 15 cm of sediments from the Northwest Arm are considerably higher than those reported for many other industrialized or highly polluted areas such as San Francisco Bay, the New York bight dump site, Tokyo Bay, and Puget Sound near Seattle but below the levels measured in the South Arm of Sydney Harbour and the Saguenay Fjord in Quebec (Gearing et al. 1991). Other locations in the Harbour have PAH concentrations ranging from less than 1.0-36.3 g/g (Tay et al. 1992, S. MacKnight pers. comm. from Gearing et al. 1991) to 2 996 g/g near a thermal-fired generating station (Tay et al. 1992). Concentrations of PAHs in the bottom 30 cm of sediments are comparable to those reported from clean, offshore areas (Gearing et al. 1991). Concentrations of PAHs in sediments at various locations in Halifax Harbour frequently exceed the ocean dumping guideline limits and the PEL (Figure 5-8) (Environment Canada 1995 as cited in Stewart and White 2001, CCME 2002b, Hellou et al. 20002b).

Biota

Mercury levels in fish caught off Halifax Harbour in the early 1970s were relatively low, and all were below 0.5 ppm, the allowable limit for commercial fish in Canada and the U.S. (Freeman et al. 1974). In the early 1980s, cod sampled in inshore areas off Terence Bay (Unit 4) had PCB levels elevated above background, although comparable to those of cod from other coastal areas (Freeman et al. 1982). An analysis of DDT levels in cod liver from six areas in Nova Scotia and New Brunswick indicated that highest concentrations (14 g/g wet weight) were found off Halifax (Sims et al. 1975). In a later study, Freeman et al. (1984) found PCB, organochlorine pesticide and chlorobenzene levels in cod livers from the Halifax area similar to those of the earlier studies, however, a decline in PCB and DDT concentrations was observed in the 1972-1975 period.

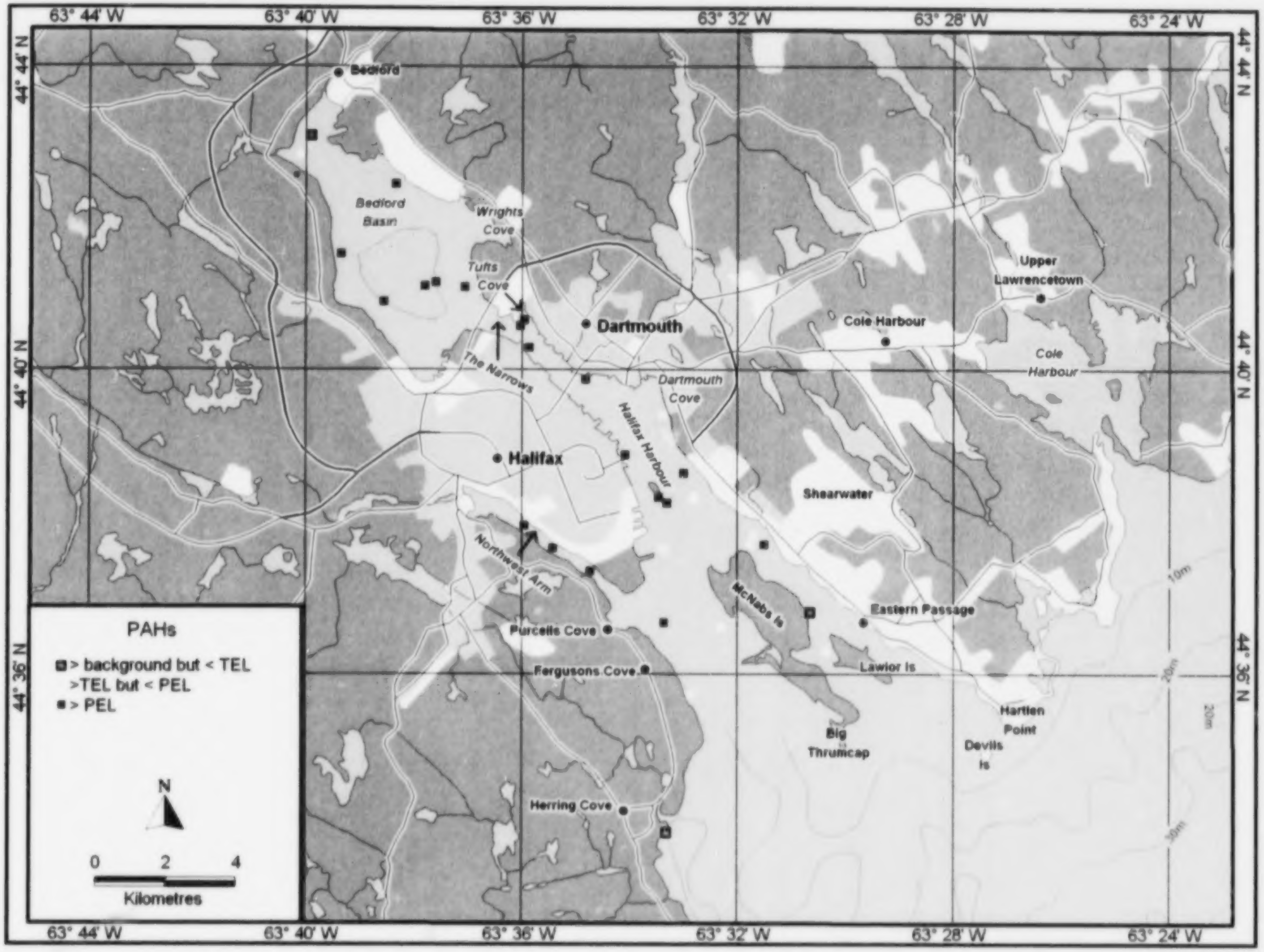

Figure 5-8: Sediment concentrations of PAHs in Halifax Harbour (based on data from Winters et al. 1991) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

Lobsters captured in 1989 in three areas in Halifax Inlet (Dartmouth Cove, Bedford Basin, including Birch Cove and Basin mouth, and Harbour mouth, including Georges Island, Point Pleasant Park and Northwest Arm) had variable but generally low concentrations of major trace metals (Cd, Cu, Pb, Hg and Zn) in their digestive glands and cooked meat (Uthe et al. 1989). Levels were below those considered hazardous to human health, however, there was some indication of elevations in particular regions of the harbour. A comparison of heavy metal concentrations in lobster from various locations in Atlantic Canada (Halifax and Victoria Beach, Nova Scotia; North Lake, Prince Edward Island; Shediac and Petit Rocher, New Brunswick) indicated that Cu and Ag levels were higher in lobsters caught near Halifax than those of other areas (Chou and Uthe 1978).

Concentrations of PCBs in digestive glands of lobsters caught in Bedford Basin and Harbour Mouth in Halifax Harbour in 1989 were below the 2.0 g/g tolerance level for PCBs in fish products (Table 5-14) (Uthe et al. 1989). However, PCB levels from lobsters captured in Dartmouth Cove were of concern due to the high concentration (5.6 g/g wet weight). Since levels in lobster meat are typically lower than those in digestive glands, Dartmouth Cove samples were considered acceptable for human consumption. Uthe et al. (1989) investigated the presence of other chlorinated organic compounds of concern but found no hexachlorobenzene and very low levels of p,p'-DDE that could not be quantified.

Levels of PAHs in digestive glands of lobsters in Halifax Harbour were higher than concentrations typical of clean areas but lower than levels that would be considered to result in unacceptable concentrations in the tail muscle, the most-consumed part of the lobster, and that caused the closing of the commercial lobster fishery in the South Arm of Sydney Harbour (Table 5-14) (Uthe et al. 1989). Polycyclic aromatic hydrocarbon levels in lobsters from within Bedford Basin and Dartmouth Cove were higher than those captured at the Harbour mouth. In the late 1970s, a hydrocarbon level of 1 630 ng/g wet weight was measured in the digestive gland of one lobster (Scarratt 1980), suggesting that Halifax Harbour was contaminated with hydrocarbons. This was the only measurement of such a high hydrocarbon concentration reported. A later study by Prouse (1991) indicated that petroleum hydrocarbon levels in lobster from various sampling sites within Halifax Harbour were not significant.

King and Chou (2003) examined lobsters from nineteen locations in eastern Canada for anthropogenic organic contaminants. They determined that lobsters caught in Halifax Harbour had the second highest PAH concentrations, with those from Sydney Harbour having the highest levels. PAH concentrations were higher in the inner parts of Halifax Harbour with known PAH sources (Dartmouth and Point Pleasant Park). Samples collected near McNabs Island, Thrumcap Shoal and Portuguese Shore indicated rapidly decreasing levels with distance from the inner harbour sources. Halifax Harbour also ranked second to Sydney Harbour for having the highest PCBs. Thus, in comparison to other harbours with major industrial and raw sewage discharge, Halifax Harbour has high PCB concentrations. In the same study, East Dover (Unit 4) had the third highest PCB levels compared to the other sites.

Studies of metal concentrations in mussels (*Mytilus edulis*) from the Halifax Inlet indicate that levels are elevated compared to other areas and suggest that elevated levels may be the result of proximity of sampling to point sources (Ward 1990). In a 1988 study by Ward (1990), levels of Cu, Pb and Zn were significantly higher than those from Beaver Harbour (considered an undeveloped Nova Scotia site) (Table 5-15) (Zenon Environmental 1989 as cited in Stewart and White 2001) and when compared to average levels for U.S. mussel watch sites (O'Connor and Beliaeff 1995). Copper, Pb and Zn levels in Halifax Harbour were also elevated above levels from the Gulf of Maine (GMCME 1996). Of the metal contaminants found in mussels from

Table 5-14: Concentrations of trace metals, PAHs and PCBs in the digestive tracts of lobster from Halifax Harbour, January and September 1989 (adapted from Stewart and White 1998).

Location	Concentration (g/g wet weight)					PAH (Total)	PCB (Total, g/g)
	Cadmium	Copper	Mercury	Lead	Zinc		
January 1989[1]							
Dartmouth Cove	0.34	199.0	0.24	0.164	25.0	2.34	5.6
Bedford Basin	0.66	69.7	0.11	0.244	24.5	2.77	1.4
Harbour Mouth	0.65	35.6	0.13	0.175	20.8	1.19	1.2
September 1989[2]							
Dartmouth Cove	-	233.8-239.7	0.13-0.19	-	-	-	-
Bedford Basin (Birch Cove)	-	99.5-139.0	0.10-0.13	-	-	-	-
Northwest Arm	-	15.4-31.2	0.11-0.13	-	-	-	-
Outer Harbour-Portuguese Shoal)	-	45.1-84.1	0.09	-	-	-	-
Outer Harbour-Thrumcap Shoal	-	74.0-95.3	0.09	-	-	-	-
Background							
Halifax Area[3]	4.64-15.1 (avg. 8.59)	25.4-426 (avg. 120)	-	-	20.6-43.2 (avg. 27.7)	-	-

[1] Uthe et al. (1989)
[2] Prouse (1991)
[3] Chou and Uthe (1978)

Table 5-15: Concentrations of contaminants found in mussels from Halifax Harbour and its approaches

Contaminant	Concentration (g/g wet weight unless otherwise specified)					
Metals	Dartmouth Cove, 1989[1]	Bedford Basin, 1989[1]	Halifax Inlet, 1988, range from various locations[2]	Halifax Harbour (3 locations)[3]	Undeveloped Nova Scotia site (Beaver Harbour, 1989)[1]	Gulf of Maine, 1994[4]
Arsenic (As)	1.1	0.83		1.9-2.5	1.6	
Cadmium (Cd)	0.44	0.17		0.06-0.29	2.1	1.1-3.1
Chromium (Cr)	0.57	0.31		0.14-0.30	0.48	0.8-3.13
Copper (Cu)	1.3	1.9	13.1-154.3	1.5-2.4	1.2	4.5-9.3
Iron (Fe)	57	32.0				170-1033
Lead (Pb)	2.4	3.9	0.4-12.1	0.11-2.2	< 0.5	1-8.3
Mercury (Hg)	0.039	0.11		0.008-0.038	0.064	0.11-1.31
Silver (Ag)	< 0.3	< 0.3		0.007-0.22	< 0.3	ND-1.05
Zinc (Zn)	41	24	92.1-280.6	17-27	11	54-153

[1] Zenon Environmental 1989 as cited in Stewart and White 2001
[2] Ward 1990. Values given are in dry weight (g/g).
[3] Hellou et al. 2003.
[4] GMCME 1996. Values given are in dry weight (g/g); to convert to wet weight divide by 6.7.

Halifax Harbour in a survey performed by Environment Canada, only Pb and Zn had levels significantly elevated above those from Beaver Harbour (Zenon Environmental 1989 as cited in Stewart and White 2001). The highest Cu levels, measured in mussels from Wrights Cove, Cow Bay and the Eastern tip of the inlet, were above the food guideline limit (30 g/g) for mollusc exports to Australia (DFO 1989).

Mussels from a mostly residential site within the Northwest Arm had the lowest PCB concentrations but similar levels of PAC and coprostanol, and the highest concentrations of Cd, Cu, Pb and Hg (Hellou et al. 2003). Cadmium, Pb and Hg concentrations in gonads from the site near Ferguson's Cove, and Sn from the downtown and Ferguson's Cove sites show an increasing trend with time. Soft tissues display similar trends where concentrations of Cd, Pb, Hg, tin (Sn) and Zn increase with time for male and female mussels at the two sites.

Hellou et al. (2002a, b) analyzed mussels around the perimeter of Halifax Harbour for the presence of PCBs and PAHs, respectively. Results showed temporal and spatial variability of PCBs and PAHs. PAH concentrations in mussels were within values reported elsewhere but much higher than in remote areas. PCB concentrations were within the lower range of levels observed in mussels from ten locations along the U.S. Atlantic and Pacific coasts (Ylitalo et al. 1999) and similar to those reported for other locations in Nova Scotia (Jones et al. 1998).

Gatermann et al. (1999) determined levels of nitro and polycyclic musks in Canadian aquatic fauna. Samples from densely populated areas, Halifax Harbour and the Miramichi estuary, showed relatively high concentrations of musk ketone (MK) and galaxolide (HHCB) compared to sparsely populated areas whereas most samples had low concentrations of musk xylene (MX) and tonalide (ATHN). Of all the fauna tested from various locations, clams from Halifax Harbour had the highest concentrations of nitro and polycyclic musks. Mussels from the Harbour also had relatively high concentration of MK and HHCB. Gatermann et al. (1999) suggest that the high MK biota concentrations may be due to very high MK water concentrations at the sample site. Of various fish oil samples tested, pollock oil from a fish caught in the Halifax area had the highest concentration of MX and MK whereas musks in the majority of other samples were not detectable.

Tributyltin (TBT) causes the development of a penis and vas deferens in female neogastropod snails and thus this "imposex" phenomenon is used as a bioindicator of TBT contamination (Prouse and Ellis 1997). Prouse and Ellis (1997) surveyed the occurrence of imposex in the dogwhelk (*Nucella lapillus*) in eastern Canada along the Atlantic seaboard into the St. Lawrence estuary. Imposex occurred at 13 of 34 sites throughout the region but at generally less than 100% frequency. However, in Portuguese Cove in Halifax Harbour all females were affected. At sites where imposex occurred, TBT concentrations ranged from 1-75 ng/g wet weight whereas imposex-free sites had concentrations < 11 ng/g or not detectable.

Hellou et al. (2003) assessed bioindicators of health in mussels at various sites within Halifax Harbour. At a downtown site close to several raw sewage effluents and a naval dockyard, twice as many male as female mussels were collected. Mussels at this site had the highest levels of PACs, coprostanol, Ag and Sn; males had a high lipid content; and females had a delayed production of vitellins. Since silver (Ag) and coprostanol are sewage markers in sediments, their presence in mussels confirms exposure to sewage effluents. Although the high levels of coprostanol in mussels from the downtown site indicated that they had been exposed to sewage effluents, no estrogenic effects were found. However, the results suggest masculinization of *Mytilus edulis*. A component analysis indicates that Ag, Sn, total PAC, coprostanol and sex ratio are strongly associated. At a site near Ferguson's Cove, outside the industrialized part of the Harbour but with higher marine traffic, females were more abundant; had higher levels of vitellins in their gonads; and had similar metals to mussels at the downtown site (Hellou et al. 2003). Hellou et al.'s (2003) observations suggest endocrine disruption in mussels at the downtown and Ferguson's Cove sites. However, while masculinization occurred at the former site, a feminization effect is apparent at the latter site. The large number of males, the high lipid content in males, and the lower levels of vitellins and delayed onset of vitellogenesis in female gonads at the downtown site is indicative of androgenic effects caused by organotin compounds.

Hellou et al. (2000) investigated two parameters, condition index and lipid content, that are indicators of the well being of mussels in Halifax Harbour. Condition index refers to a comparison between the soft tissue content of bivalves relative to their external dimensions, where stress has been observed to reduce growth. Exposure of marine aquatic organisms to pollution, especially PAHs, can lead to lipid metabolism impairment, causing an increase in lipid content and changes in lipid transport. Hellou et al. (2000) determined that mussels from the downtown site in Halifax Harbour displayed the highest condition indices and lipid contents whereas those from the Northwest Arm site had some of the lowest values. The downtown site also had elevated PAH concentrations compared to some of the lowest values found in the Northwest Arm and Bedford Basin.

Ernst et al. (1994) determined that the "treated" leachate from a settling pond outlet receiving drainage from a landfill was highly toxic to rainbow trout *Oncorhynchus mykiss*), and brook trout (*Salvelinus fontinalis*), and moderately toxic to the water flea (*Daphnia magna*). However, at the point where the leachate left a natural swamp further downstream and entered the Sackville River it was only moderately toxic to fish and not acutely toxic to water fleas. Several parameters measured at the outfall (e.g., arsenic (As), ammonia and iron) were above the Canadian freshwater quality guidelines for the protection of aquatic life (Table 5-4). The ammonia content was thought to be responsible for the toxicity of the leachate.

In a follow-up study four years later, Rutherford et al. (2000) determined that the leachate was not toxic to rainbow trout, water fleas or the gram negative, bioluminescent bacteria, *Vibrio fischeri*. There were no detrimental effects on survival or reproduction of the water flea, *Ceriodaphnia dubia*, although a slight effect on reproduction was detected upstream at the control site. Moderate toxicity to the green alga, *Selenastrum capricornutum*, was detected at the control and 40 m downstream from the outfall. No cytotoxic effects were detected, however, very slight mutagenic effects were detected in the final leachate and at 40 m downstream from the outfall. Leachate discharge had a localized impact on community structure near the outfall but by 50 m downstream, conditions were approaching those upstream of the discharge site. Some water quality parameter (e.g., Al, Ni, Fe and Cu) concentrations exceeded the Canadian freshwater quality guidelines for the protection of aquatic life (CCME 2002a) downstream of the landfill. The same metals also exceeded the guidelines at the control station. In terms of aquatic toxicity, these results indicate a marked improvement in the quality of the leachate discharged from the landfill in 1993 (Rutherford et al. 2000), as compared to1989 (Ernst et al. 1994), which is likely a result of the wastewater treatment upgrades in the early 1990s.

In a laboratory study, Pan and Subbao Rao (1997) evaluated the impact of domestic sewage effluent (SE) on the dynamics of phytoplankton assemblages from Bedford Basin. They found that phytoplankton production and chlorophyll *a* increased proportionally with SE enrichment. Phytoplankton species composition also changed, with potentially harmful diatoms, *Pseudo-nitzschia* spp., initially present only in small numbers but increasing when the seawater was enriched with 0.5-5% untreated SE. Other harmful species such as *Fragilaria* spp. and *Euglena* spp. became dominate with higher proportions of SE. The three aforementioned species are either harmful or are associated with eutrophication and formation of phytoplankton blooms (Pan and Subbao Rao 1997). *Pseudo-nitzschia multiseries* causes amnesic shellfish poisoning which can be fatal to humans, and *Euglena* and *Fragilaria* are associated with eutrophication, formation of blooms and anoxic conditions (Vilaclara et al.1988). Thus, the results of Pan and Subbao Rao's (1997) study suggest that addition of SE to natural seawater may cause increased populations of harmful diatoms at the expense of naturally occurring benign diatoms.

St. Margarets Bay

Analysis of organochlorine residues in demersal fish and benthic invertebrates from shallow (5-20 m) and deep (60-75 m) areas of St. Margarets Bay indicated a lack of DDT residue accumulation (overall mean 10.5 8.8 ppb, wet tissue) in the benthic food chain (Hargrave and Phillips 1975). DDT and its metabolites were the only organochlorine compounds present in sufficient quantities for detection in fish and invertebrates from St. Margarets Bay. Faunal concentrations of DDT residues in the area are among the lowest recorded for marine fish and invertebrates. DDT levels in copepods (*Calanus* spp.) (< 1 ng/g wet weight) (Darrow and Harding 1975) and mercury levels in Atlantic mackerel (*Scomber scrombrus*) from St. Margarets Bay were also low (< 0.005-0.16 g/g wet weight) (Freeman et al. 1974). PCB levels were not detected in copepods (Darrow and Harding 1975). Petroleum hydrocarbon concentrations in water from St. Margarets Bay (Unit 4) were comparable to those of oceanic waters (Gordon et al. 1978).

The Head of St. Margaret's Bay has experienced an increase in the size of its shellfish closure area in the past two years. Current research attributes land-based development as the major cause of marine pollution. Shellfish, with their ability to filter large amounts of water, are considered an indicator species for declining water quality due to chemical and bacterial contamination from point and non-point source pollution (Barrington et al. 2003)

Eastern Shore

Petpeswick Inlet

In a study of contaminants in sediments, all metals (zinc, copper, mercury, lead, arsenic) in Petpeswick Inlet (Unit 5) were at or near natural concentrations, with the exception of cadmium (Loring et al. 1996) (Figures 5-9 to 5-13). Sixty percent of the samples obtained contained cadmium levels > 0.3 mg/kg, with the highest concentrations occurring in the upper part of the

Inlet. Cadmium concentrations in the upper part of the Inlet exceeded the TEL (CCME 2002b). The main sources of contaminants in Petpeswick Inlet are organic waste discharged from local habitations. Loring et al. (1996) suggest that the high concentrations of cadmium are associated with the trapping and deposition of organic-rich particles from local sewage disposal at the head of the Inlet.

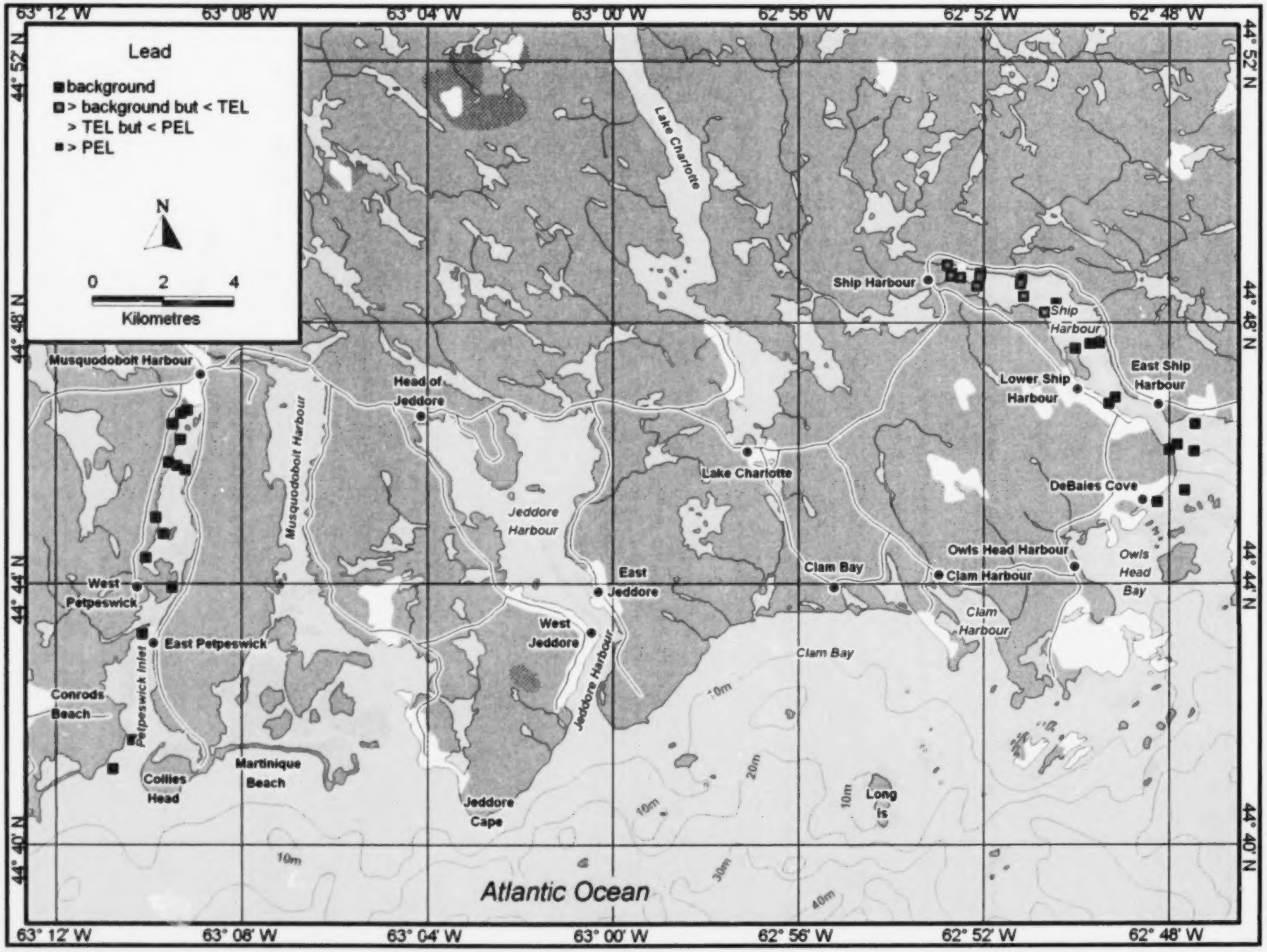

Figure 5-9: Sediment concentrations of lead in Petpeswick Inlet and Ship Harbour (based on data from Loring et al. 1996) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

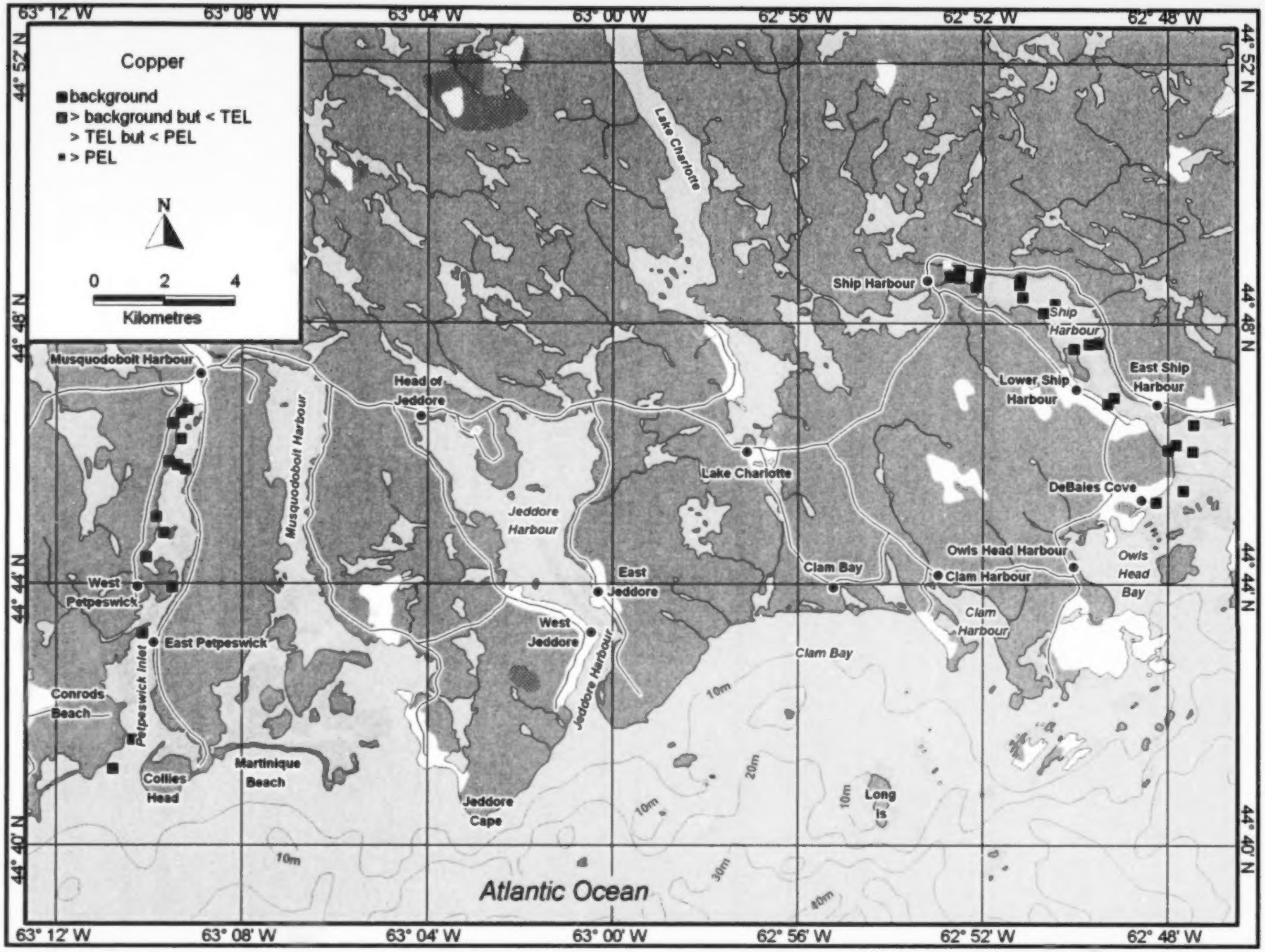

Figure 5-10: Sediment concentrations of copper in Petpeswick Inlet and Ship Harbour (based on data from Loring et al. 1996) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

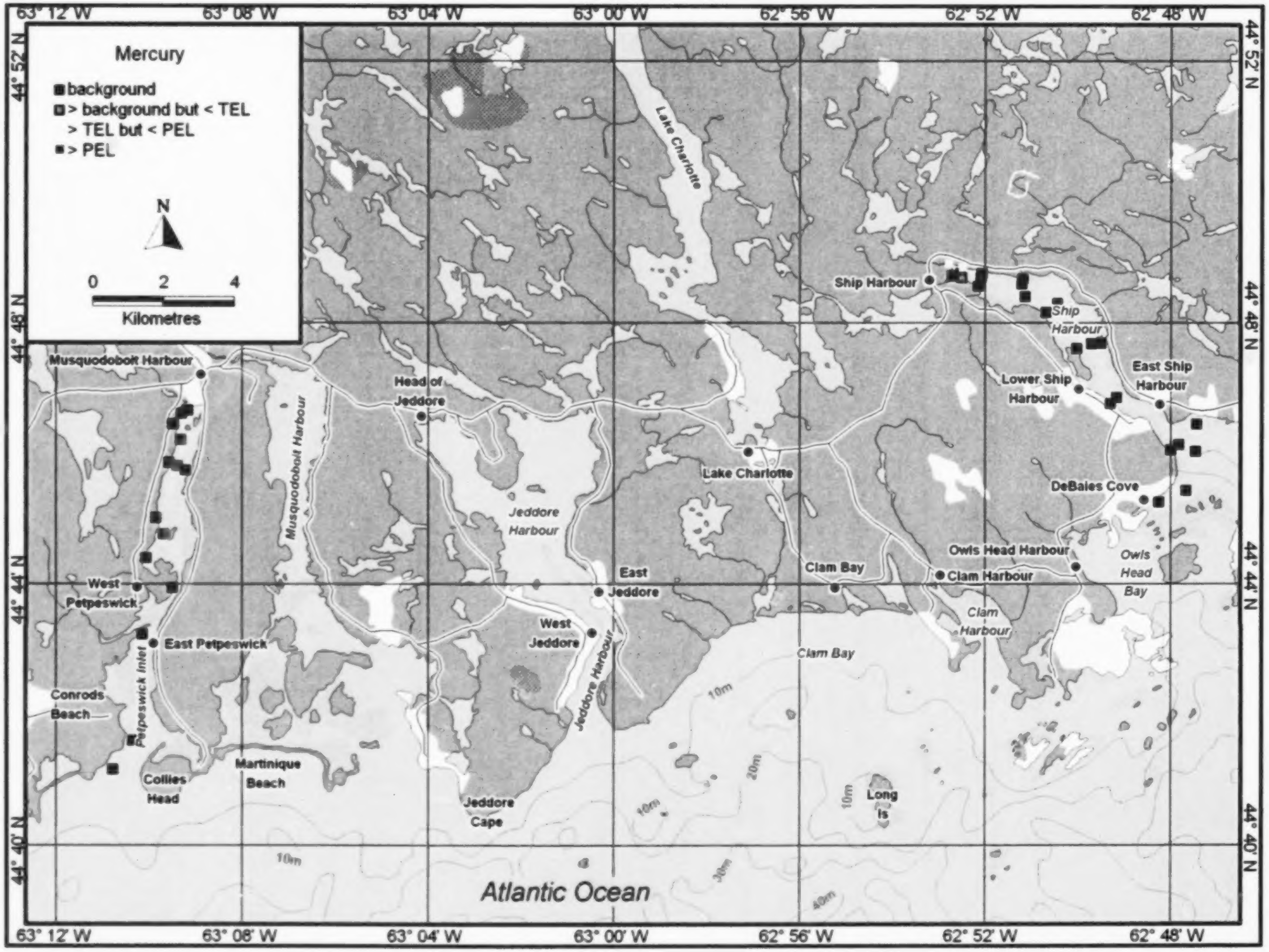

Figure 5-11: Sediment concentrations of mercury in Petpeswick Inlet and Ship Harbour (based on data from Loring et al. 1996) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

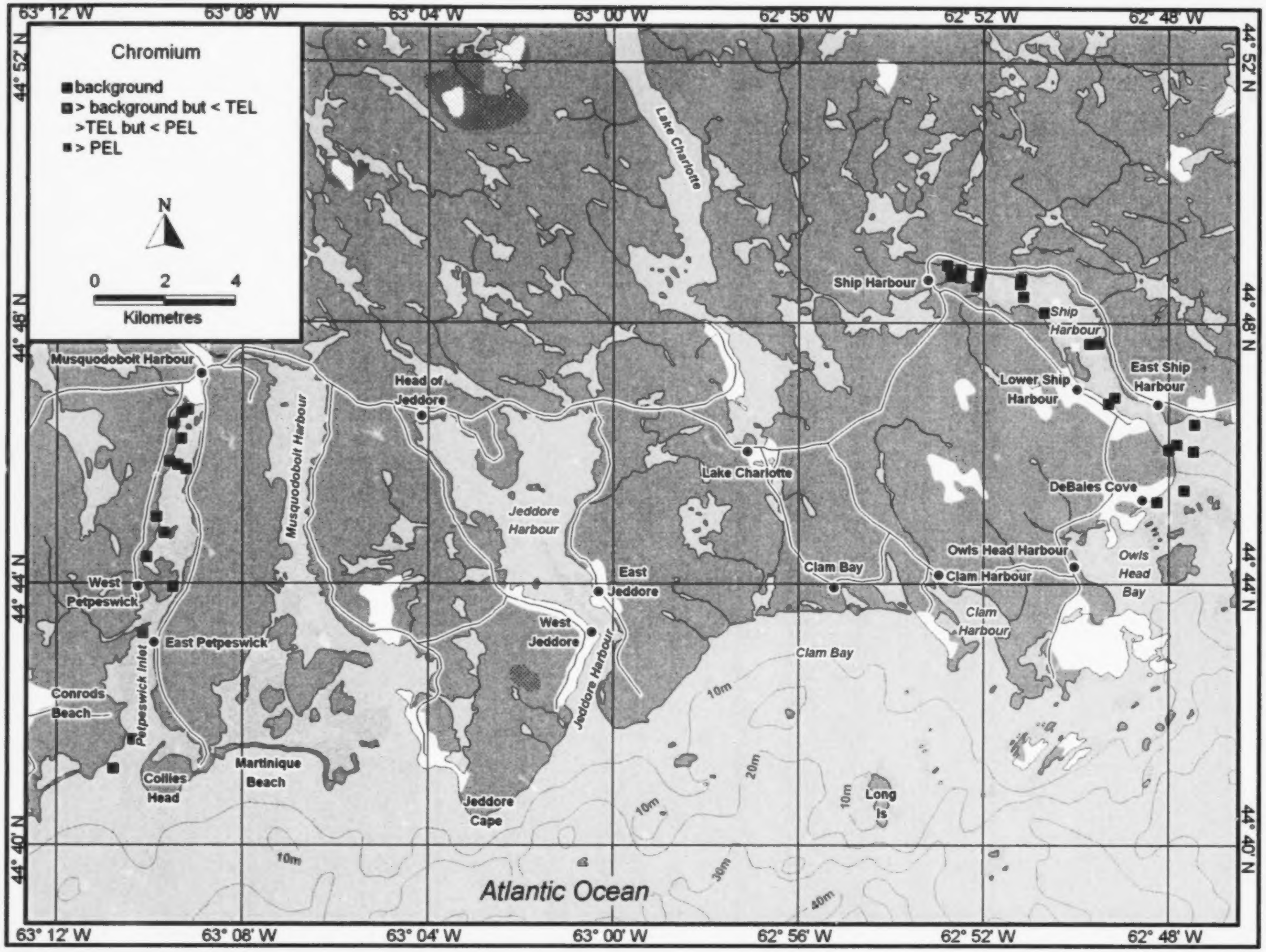

Figure 5-12: Sediment concentrations of chromium in Petpeswick Inlet and Ship Harbour (based on data from Loring et al. 1996) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

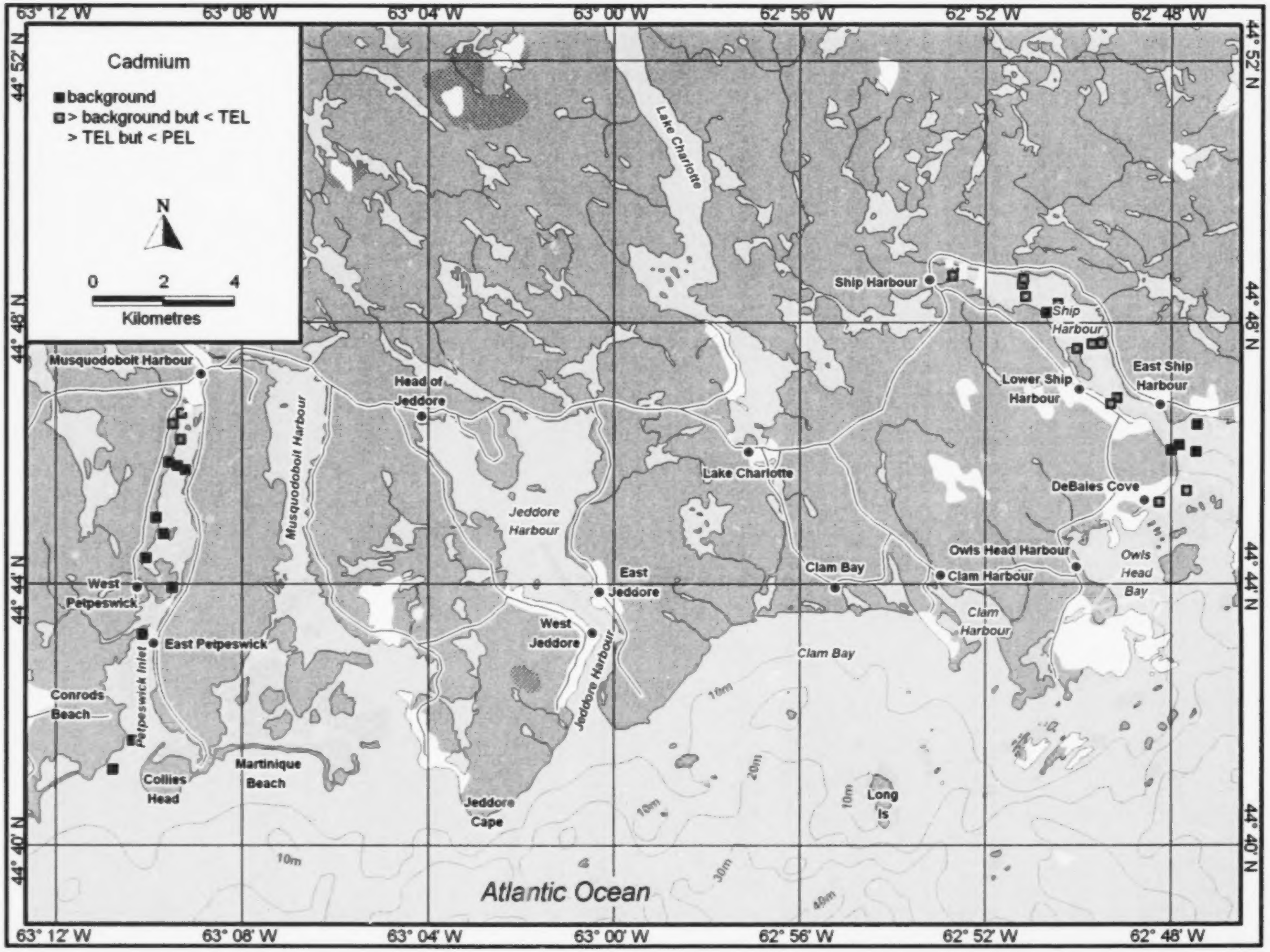

Figure 5-13: Sediment concentrations of cadmium in Petpeswick Inlet and Ship Harbour (based on data from Loring et al. 1996) with respect to MEQ thresholds (CCME 2002b). Basemap layers (NRCan).

Ship Harbour

Most of the metal contaminants in sediments in Ship Harbour (Unit 6) are at or near natural concentrations (Loring et al. 1996) (Figures 5-9 to 5-13). However high cadmium concentrations (>0.3 mg/kg) occur in 92% of samples, with 63% exceeding the limit for ocean dumping (0.6 mg/kg) and 21% containing concentrations >1 mg/kg. In 17% of the samples, Hg and Pb exceed their normal background levels. The inner Harbour has concentrations of Cd, Pb, Cu and Hg that exceed the TEL. Chromium (Cr) levels in the central Harbour exceed the TEL. Three surveys of metal concentrations in water in Ship Harbour yielded concentrations for Cd, Cu, Fe, Mn, Ni, Pb and Zn that are essentially at coastal water background levels (Strain and Yeats 2002).

The potential inputs of harmful substances from local inhabitants and mussel aquaculture activities are the only known sources of contaminants into Ship Harbour. Loring et al. (1996) suggest that the high concentrations of Cd and Hg are likely a result of biological activity and organic waste deposited in the estuary. Petroleum residue concentrations in sediments from Ship Harbour were below the regulated limit defined by the *Ocean Dumping Control Act* (Levy et al. 1988).

Other areas

A study of organohalogens in sediments in coastal areas by Leonard (1977) indicated that most of the sediment samples from HRM had DDT levels at or below the detection limit. A sample taken from Three Fathom Harbour was the exception with 6 ppb DDT which is above the background level of 2 ppb DDT (Leonard 1977).

Analysis of sediment cores from the salt marsh in the West Head of Chezzetcook Inlet indicates elevated concentrations of Fe, Ni, cobalt, Mo and As near the surface of the marsh sequence at the landward edge of the marsh (Chagué-Goff 2001). The elevated levels are attributed to anthropogenic input related to the recent road construction but are fairly localized in the marsh.

Mercury concentrations in Atlantic salmon (*Salmo salar*), herring (*Clupea harengus*), halibut (*Hippoglossus hippoglossus*), haddock (*Melanogrammus aeglefinus*), hake (*Urophycis chuss*), cusk (*Brosme brosme*), pollock (*Pollachius virens*), catfish (*Anarhichas lupus*), lumpfish (*Cyclopterus lumpus*), menhaden (*Brevoortia tyrannus*), squid (*Loligo forbesi*) and rock crabs (*Cancer irroratus*) caught near Little Harbour (Unit 5) were below 0.5 ppm, the limit allowed for commercial fish in Canada and the U.S. (Freeman et al. 1974).

Dalziel et al. (1998) gathered information on the input of toxic chemicals into coastal waters of Nova Scotia and New Brunswick through run off. During the period of 1992-1996, a series of rivers were sampled from mainland Nova Scotia, two of which are located in Halifax Regional Municipality: Musquodoboit River (Unit 5) and East River Sheet Harbour (Unit 6). Compared to other rivers, East River Sheet Harbour had high dissolved oxygen content (DOC) values and the Musquodoboit River had elevated values of nitrate plus nitrite. DOC values exceeded Canadian freshwater quality guidelines for the protection of aquatic life in both rivers on several occasions (CCME 2002a). Mercury levels from both rivers were below the mercury guideline (CCME

2002a). Dissolved Zn, Ag, Ni and As levels in both rivers were also below the guidelines. Both rivers occasionally had Cu levels that exceeded the guideline. Iron levels in Sheet Harbour frequently exceeded guideline levels.

Of 65 locations sampled for petroleum residues in sediments along the shores of New Brunswick, Prince Edward Island and Nova Scotia, Bayswater Beach (Unit 4), an area devoid of industrial and residential developments, had the lowest concentrations of petroleum residues in HRM and of all the sites sampled (Levy et al. 1988). Petroleum residue concentrations in sediments from Sheet Harbour were also below the regulated limit defined by the *Ocean Dumping Control Act* (Levy et al. 1988).

Conclusion

As the most populated and industrialized inlet on the Atlantic coast of Nova Scotia, Halifax Harbour shows significant anthropogenic contamination. The data available for metals and organics in sediments suggest that Halifax Harbour has substantive areas with concentrations greater than the PEL for Pb, Cu, Hg, Zn, PCBs and PAHs. Several of the metals have concentrations at or near background levels in the approaches to the Harbour. The general trend for contaminants in sediments in the Harbour is for concentrations to increase from its approaches to the inner Harbour. Documented biological effects on dogwhelks and mussels in the Harbour also indicate significant contamination (e.g., TBT).

Other coastal areas in HRM show contamination, although to a lesser extent. Several metals (Cd, Pb, Cu, Hg) in sediments are at concentrations above the TEL in inner Ship Harbour. Of coastal sites sampled in HRM, Sheet Harbour and Eastern Passage had the highest concentrations of PCBs, exceeding background levels.

Much of the contamination in HRM is localized, concentrated around industrial facilities and sewer outfalls. For example, in Eastern Passage high PCB concentrations were found near refineries and wharves, and elevated petroleum residue concentrations in Northwest Arm sediments were located near mooring facilities and adjacent to a sewage outfall. Thus some localized contamination adjacent to wharves and centres of population is expected.

In SHACI Units 4-6, there are areas of significant contamination such as Halifax Harbour and minor contamination in other areas. However, it should be noted that there is limited information on contamination of biota, water and sediments by metals or organic compounds in the majority of coastal areas along the Atlantic coast of Nova Scotia. In many cases, contaminant studies are targeted at areas of concern and thus do not provide a comprehensive account of the contamination status of most coastal areas within HRM.

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6 - Physical oceanography

This chapter provides an overview of the physical oceanography of Nova Scotia's inner shelf and coastal area off Halifax Regional Municipality (SHACI units 4-6). The currents, temperature and salinity, sea level, waves, ice cover and meteorology vary substantially throughout the year and interannually. They strongly influence the biological productivity, chemical distributions and sediment-coastline dynamics of inshore waters.

A large amount of physical oceanographic data has been collected and archived at the website http://www.mar.dfo-mpo.gc.ca/science/ocean/home.html by the Ocean Sciences Division (OSD) of Fisheries and Oceans Canada and at the national website http://www.meds-sdmm.dfo-mpo.gc.ca/ of the Marine Environmental Data Service in Ottawa. These data have been used to provide a description of the ocean environment and its variability, a focus for studies of specific oceanic processes, and the potential to validate models of the tidal and seasonal circulation of the inner shelf. Besides the open shelf, a considerable amount of data have been collected in the inlets of this region, particularly in Ship Harbour, Halifax Harbour and St. Margarets Bay. The data have been collected from ships, by moored instruments and from satellites. A recent overview for the entire shelf was presented by Breeze et al. (2002).

The mean and varying conditions in this coastal ocean environment are determined by a number of processes: wind, heat exchange between the atmosphere and the ocean, outflow from the Gulf of St. Lawrence in the Nova Scotia Current, intrusions of offshore waters, tides and fresh water inflows from the land. Within the inlets, fresh water inflow, exchange with the shelf driven by wind or by coastal flows, and tidal currents within the inlet are dominant factors. In the coastal region and within the inlets, the topography and the coastline configuration can also be important factors. Variability in the coastal ocean occurs over time scales varying from seconds (e.g., surface waves), hours (tides), days (wind-forced currents), annually (solar cycle) and interannually (large scale changes in the circulation of the adjacent ocean or atmosphere (see for example, Petrie and Drinkwater 1993; Loder et al. 2001).

This overview will focus on SHACI Units 4-6; it provides greater detail of the local oceanography than the review of Breeze et al. (2002) which presents a broader, shelf-wide description. The mean and variable circulation, temperature and salinity distributions, sea level, wave statistics, ice and meteorological conditions are described using a mixture of observations and model results.

Circulation

The Nova Scotia Current is the dominant alongshore flow on the inner half of the Scotian Shelf (Figure 6-1). This current originates in the Gulf of St. Lawrence, flows through Cabot Strait into Sydney Bight and is sometimes supplemented by waters from the Newfoundland Shelf that cross the Laurentian Channel. It brings generally fresher, colder water from the Gulf onto the Scotian Shelf; these waters also make a significant contribution to the circulation and water properties in the Gulf of Maine. The Nova Scotia Current has two branches, one which flows along the inner Scotian Shelf and an offshore branch that follows the shelf break. This general picture of the mean circulation has been built from data from hydrographic surveys, long-term sampling at fixed stations, drift bottle releases, limited current meter deployments and sea level observations (see for example, Sutcliffe et al. 1976). Model simulations of the mean circulation indicate that the Nova Scotia Current flows alongshore in the eastern boundary of SHACI units 4-6 but partially moves offshore approximately southeast of Halifax.

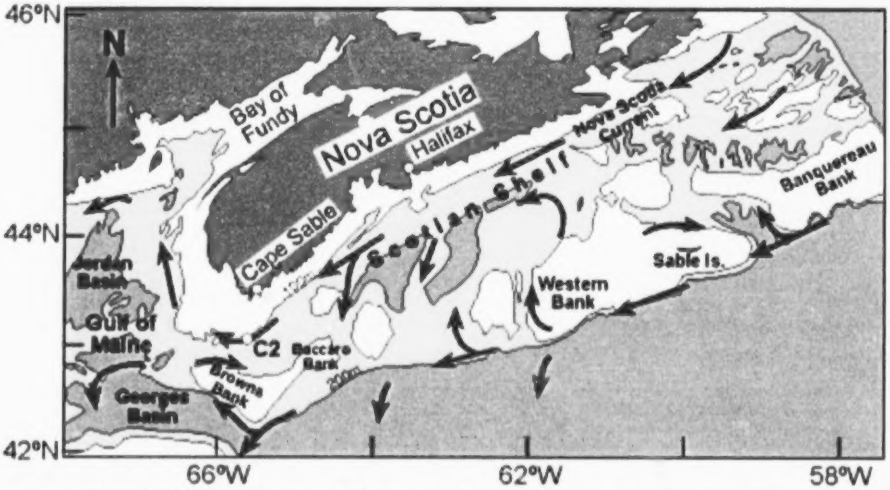


Figure 6-1: Schematic of the general circulation on the Scotian Shelf.

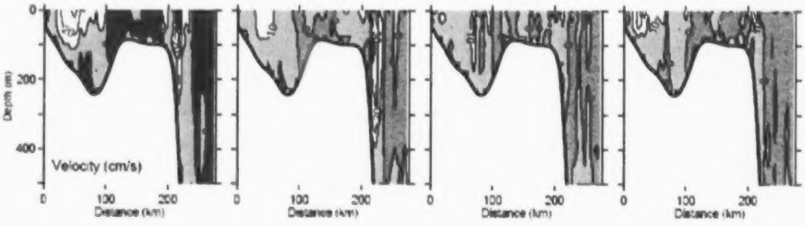


Figure 6-2(a): Seasonal along-shelf baroclinic currents (positive southwestwards, green/yellow) on Halifax Section for winter (left panel), spring, summer and fall (Loder et al. 2003)

The Nova Scotia Current has a significant annual variation with the strongest currents to the southwest and confined to the inner Scotian Shelf during winter (Figure 6-2(a); Loder et al. 2003). The largest monthly baroclinic transport in the upper 100 m, about 0.5 million cubic metres per second, is to the southwest in January (Figure 6-2(b); Drinkwater et al., 1979). These monthly mean transports for the inner half of the Scotian Shelf are based on the observed density structure on a transect that begins just off Halifax and runs southeastwards to the 2600 m isobath on the continental slope. The transport and the currents are generally weaker from July to October. The average January transport is about 5 times greater than the August value.

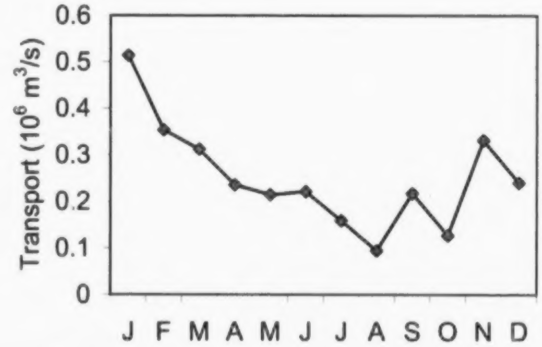


Figure 6-2(b). Monthly transports to the southwest of Nova Scotia Current 0-100 m for the inner shelf from Drinkwater et al. (1979).

Current meters have been moored in the coastal zone of the Scotian Shelf since the mid-1960s. The seasonally averaged currents are shown in Figure 6-3 where winter is defined as January, February and March, spring as April, May and June, summer as July, August and September, and fall as October, November and December. The mean winter conditions feature strong along-isobath flows of up to ~15 cm/s with generally decreasing currents with increasing depth. The currents appear to be weaker inside the 100 m isobath; the flow is strongly to the west-southwest just seaward of the 100 m isobath and is strongest farther offshore at roughly the 150 m isobath. The area of strong currents is at or near the core of the Nova Scotia Current. This flow pattern is similar to the one based on the density structure (Drinkwater et al. 1979, Loder et al. 2003). The same basic pattern is also seen in the spring with perhaps a slight decrease of the current strength. The few observations available during summer are mostly from the nearshore zone, St. Margarets Bay and Halifax Harbour. In fall, the currents again resemble the winter and spring pictures; however, they appear to be strongest during this time of year. The mean flow at 16 m, 44.32°N, 62.94°W, exceeds 30 cm/s over the fall period.

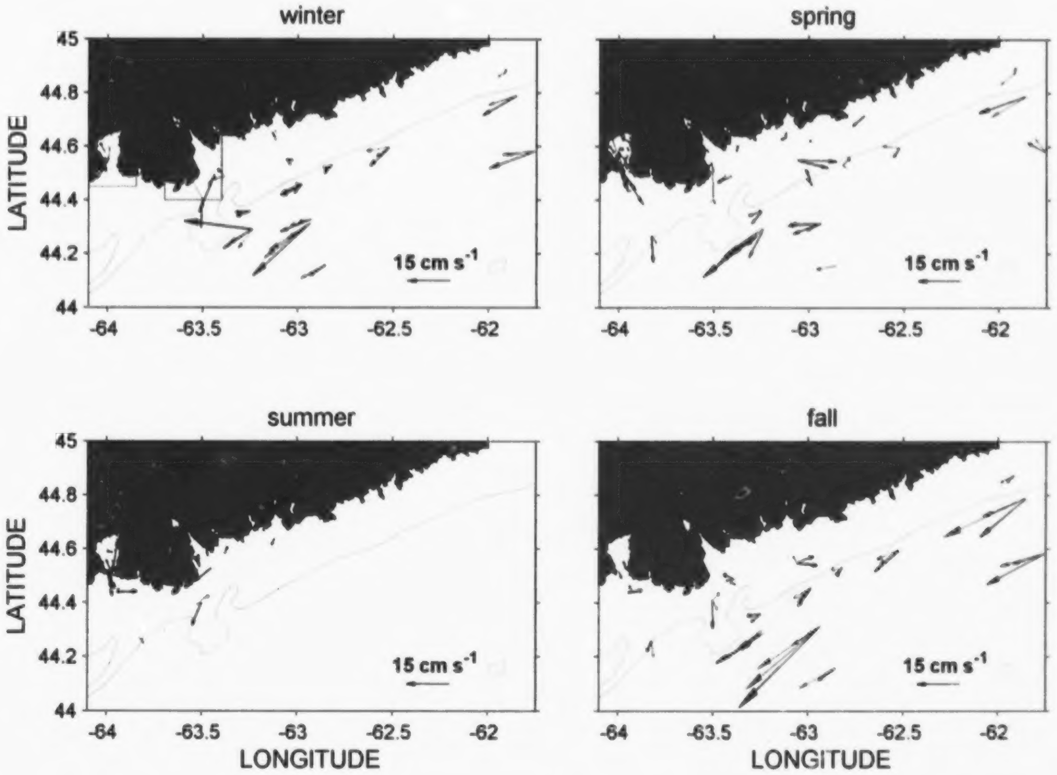


Figure 6-3: Mean currents for the inner shelf in winter (JFM), spring (AMJ), summer (JAS) and fall (OND). Black arrows are for observations from 0-30 m, red for 30-50 m, green for 50-100 m and blue for >100 m.

Current distributions are also available from model solutions for the shelf (Hannah et al. 2000, 2001). These simulations use long-term estimates of the seasonal density structure plus a fixed upstream inflow to generate seasonal, depth-dependent mean currents. Currents from the upper 5 m (Figure 6-4) have an overall accuracy for current speed of ~5 cm/s compared to observations. The dominant feature is the southwestward flowing Nova Scotia Current, as it was in the data. However, the model flow has a stronger southerly component. This may be partly because the model results are from 0-5 m, whereas most of the observations are from considerably deeper depths. In addition, the model density field could reflect wind influence which would tend to add a southerly component to the very near surface flow. Another notable feature of the model solutions is the tendency of the nearshore currents to flow towards the northeast. The influence of the coastline between Halifax Harbour and St. Margarets Bay is readily apparent. These solutions, combined with tides and wind influences, can be used to track particles released anywhere in the zone. The tool is available on the Maritimes DFO website indicated above.

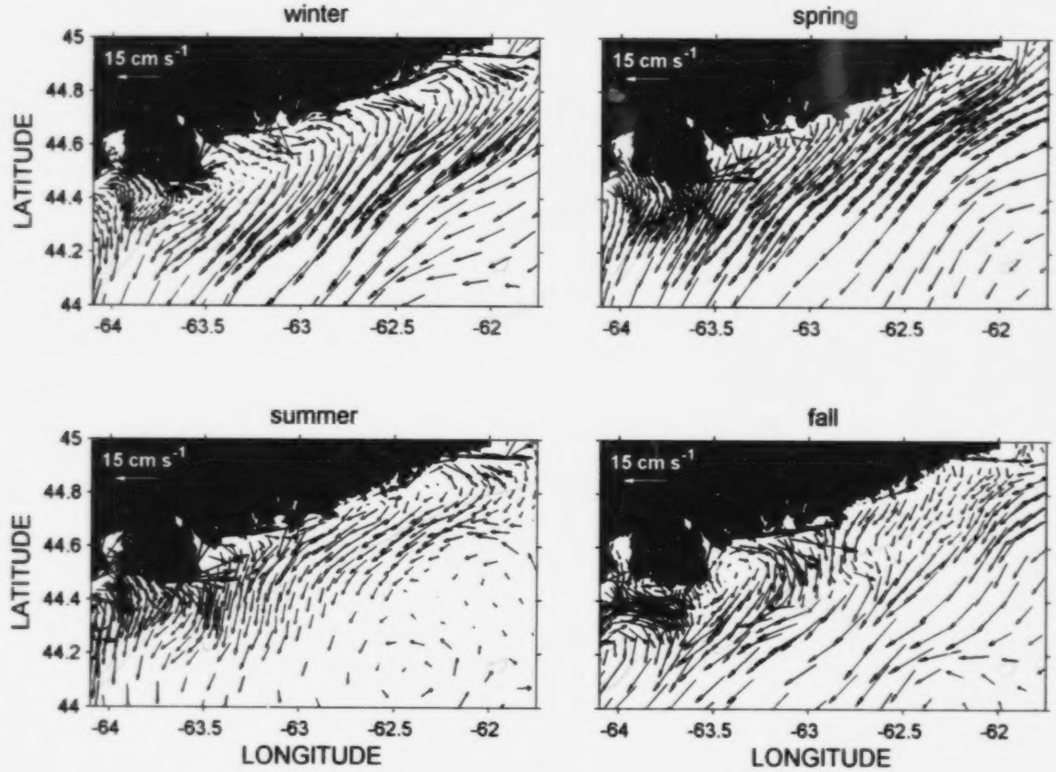
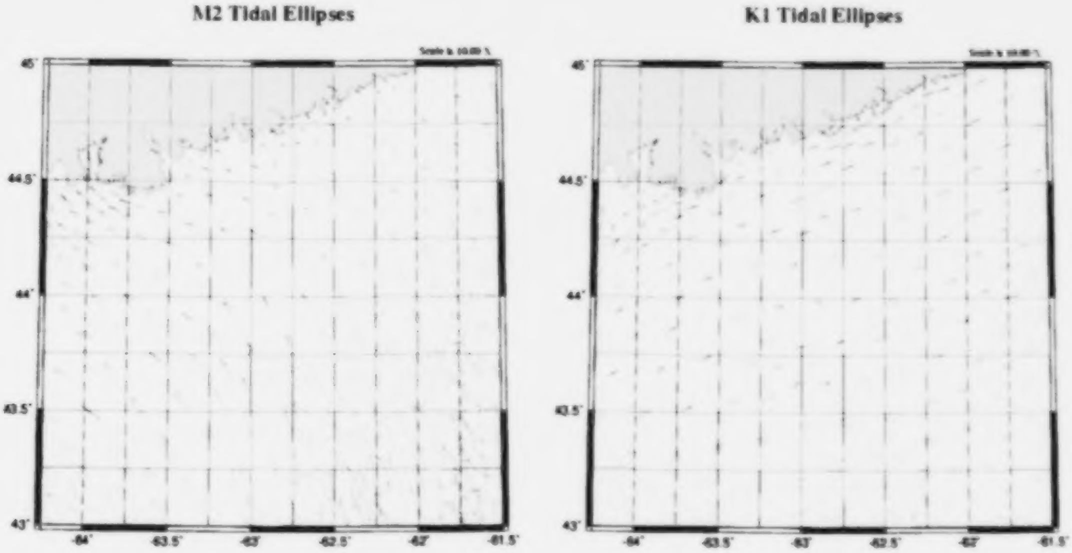


Figure 6-4: Seasonal mean currents (0-5 m) from a numerical model of the Scotian Shelf circulation.

The tidal flows make a large contribution to the currents within the region. The dominant tidal constituents are M2 (12.42 h period), S2 (12 h), N2 (12.66 h), K1 (23.93 h) and O1 (25.82 h). Figure 6-5 shows the tidal ellipses for M2, K1 and O1 (DFO 2002). The S2 and N2 constituents are not shown but are easily related to M2. The size of the S2 and N2 ellipses are about 0.22 of the M2 ellipses; the phase difference (S2-M2) is about 32°, (N2-M2) is about -22°.

The distance a particle would move over a tidal cycle is quite small when one accounts for the magnification factor of 10 in Fig. 5. For example, at 43.25°N, 61.75°W, the M2 tidal current amplitudes are 17.5 cm/s and 14.5 cm/s for the north-south and the east-west components, about the largest values in Figure 6-5. Particles in these flows would move maximum distances of 2.5 km (N-S) and 2.1 km (E-W). So while the currents are quite strong, their cyclical nature reduces the particle excursion. By contrast, a steady current of 17.5 cm/s over an M2 tidal period would move a particle of water 7.8 km.



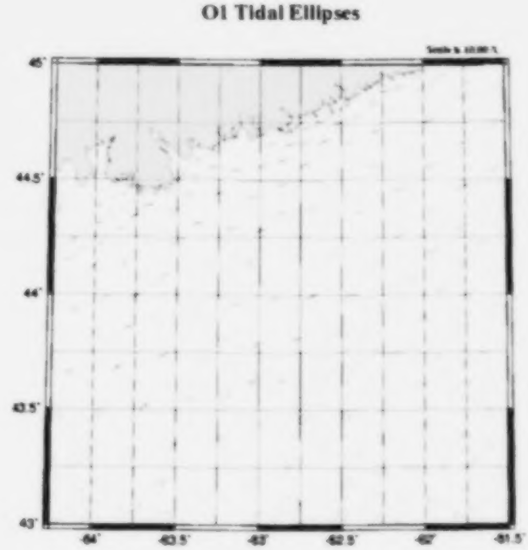


Figure 6-5: The M2, K1 and O1 tidal ellipses for SHACI areas 4-6. The ellipses represent the path a particle would take if it were responding only to the individual tidal constituent. The line from the centre of the each ellipse to its border represents the phase of the tidal current. Note that for each figure, the currents have been scaled upwards by a factor of 10, i. e., the true ellipses are one tenth of the size shown. The tidal calculations are based on a finite element, single layer model that covers the entire Scotian Shelf (Dupont et al. 2005).

In addition to the open shelf, current meter data have been collected in several inlets of units 4-6, notably St. Margarets Bay, Halifax and Ship Harbours. St. Margarets Bay was studied in the late 1960s (Sharaf El Din et al. 1970; Heath 1973). They reported that the mean circulation consisted mainly of an anticlockwise gyre, with water entering on the east side and leaving on the west side of the inlet; this is seen in the seasonal mean currents (Figure 6-6). In this figure, the black arrows represent the current from 0-10 m, red 10^+-20 m, green 20^+-30 m and blue > 30 m. The anticlockwise pattern is particularly evident in the spring, summer and fall at the mouth of the inlet. We also note that the currents at depths > 30 m are mostly towards the head of the bay, especially in spring. This may reflect an estuarine component of the circulation where the shallow flow tends to be seaward and the deep flow landward. The freshwater inflow, which could drive the estuarine circulation, varies from a monthly average high of 51 m^3/s in April, when the deep flow is towards the head of the inlet, to a low of 9 m^3/s in August. Sharaf El Din et al. (1970) showed lowered salinities near the head of the bay in some of their longitudinal hydrographic sections indicating that fresh water may play a role in the circulation. Heath (1973) concluded that wind forcing causes episodic flushing of the bay.

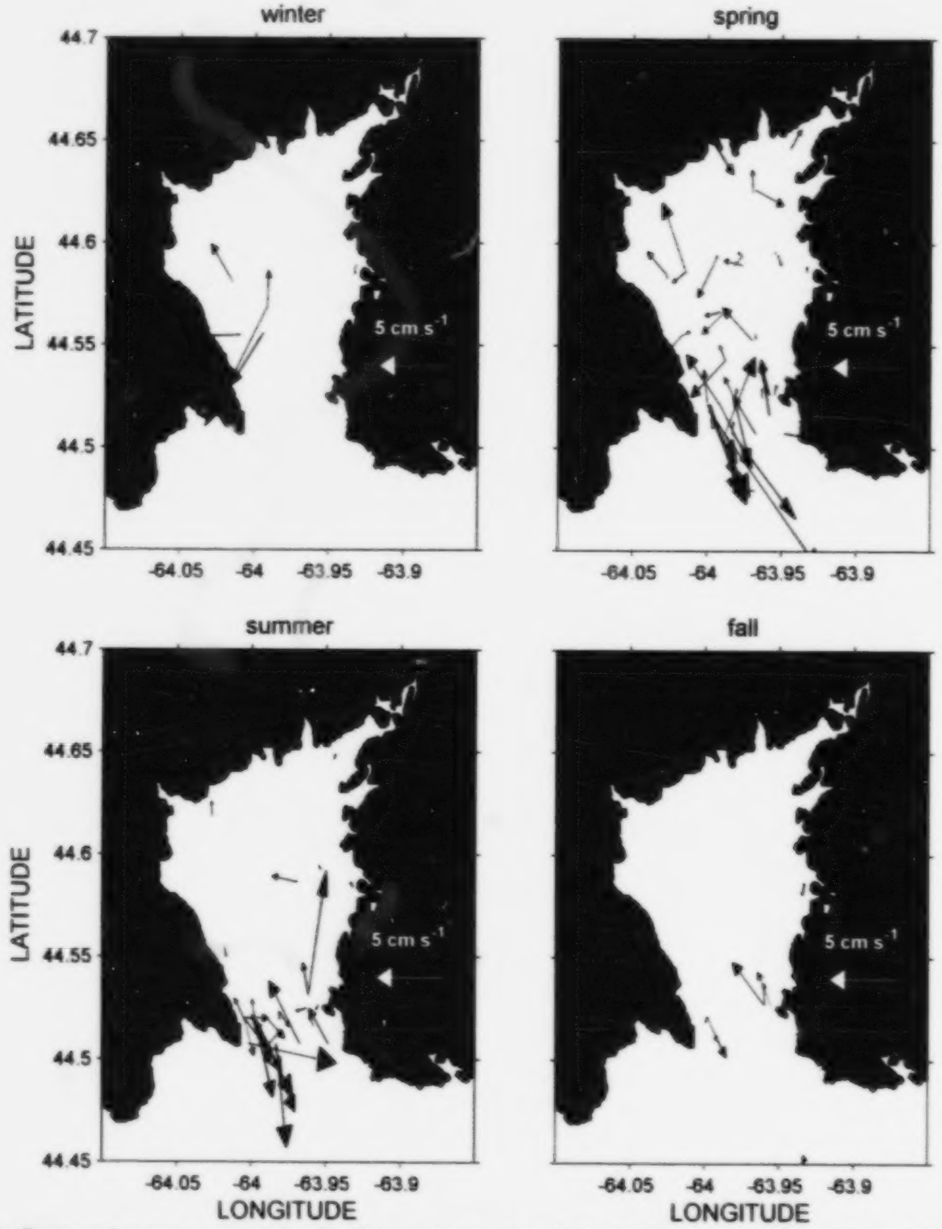


Figure 6-6: Seasonal mean currents for St. Margarets Bay for winter (JFM), spring (AMJ), summer (JAS) and fall (OND). Black arrows are for observations from 0-10 m, red for 10-20 m, green for 20-30 m and blue for >30 m.

Halifax Harbour was the subject of a one year current measurement and a two year hydrographic program in the early 1970s (McGonigal et al. 1974; Jordan 1974). Petrie and Yeats (1990) used the data to derive and verify a circulation model for the inlet based on mass and salt budgets. They found that the distribution of salinity, increasing seaward at all depths, and the current meter observations supported an interpretation of the mean circulation as estuarine, i.e. near-surface outflow and deeper inflow. Subsequently, a number of moorings were deployed in the outer harbour in studies related to waste water treatment (ASA 1986, 1990). These data and the earlier observations, are shown in Figure 6-7(a) as maps of the seasonal mean flows.

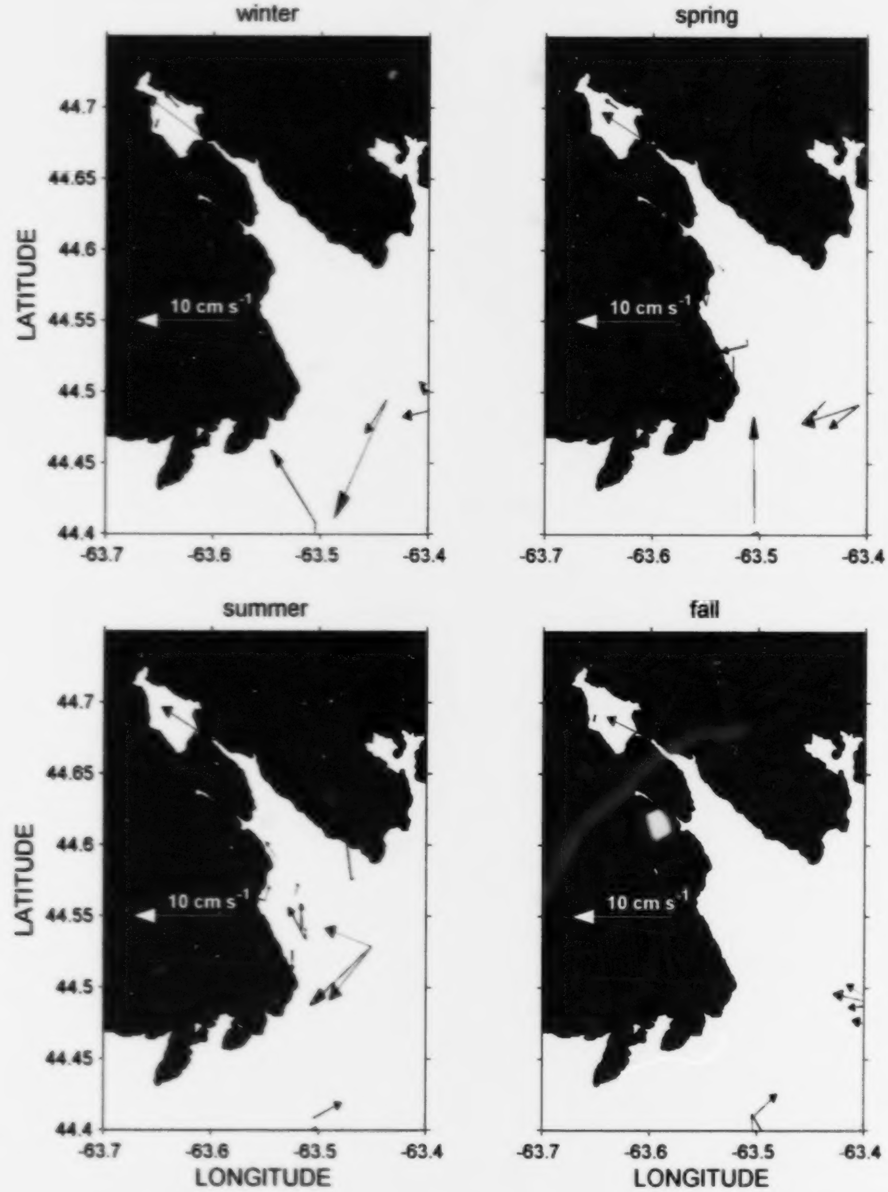


Figure 6-7(a): Seasonal mean currents for Halifax Harbour. Black arrows are for observations from 0-10 m, red for 10-20 m, green for 20-30 m and blue for >30 m.

The current vectors in the Narrows are quite variable from season to season and with depth. In part this reflects the presence of strong variability and weak mean flows. Petrie and Yeats (1990) determined the annual mean currents in the Narrows and concluded that the flows were consistent with estuarine-like circulation (Figure 6-7(b)). Monthly mean freshwater inflows vary from 31 m^3/s in April to 5.3 m^3/s in September. Most current vectors in the outer harbour are towards the head of the inlet. Petrie and Yeats (1990) found that the currents, measured by an acoustic Doppler current profiler between McNabs Island and Sandwich Point in the outer harbour, were seaward only in the upper 4 m (Figure 6-7(c)).

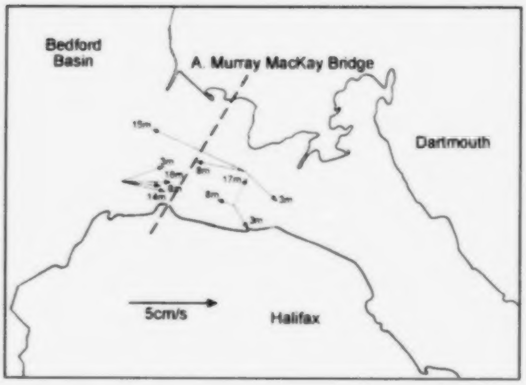


Figure 6-7(b): Annual mean currents from the Narrows in Halifax Harbour (Petrie and Yeats 1990). The numbers on the figures indicate the depths of the observations.

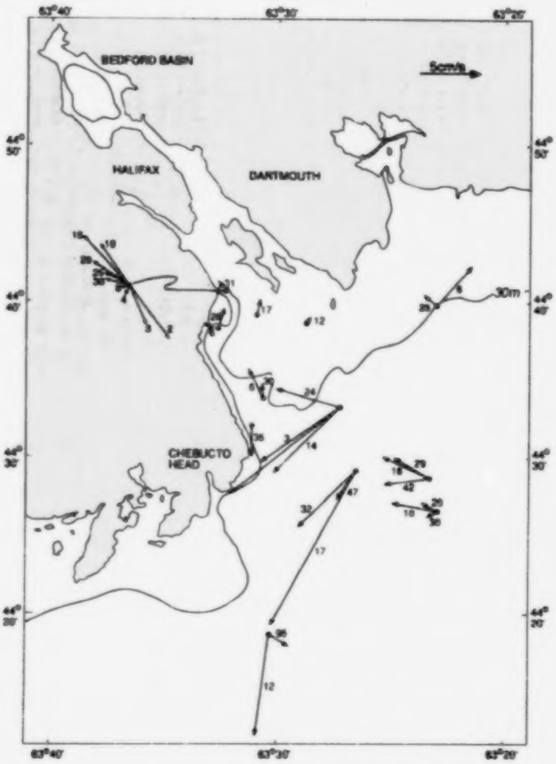


Figure 6-7(c): Average currents from the outer section of Halifax Harbour (Petrie and Yeats 1990). The numbers on the figures indicate the depths of the observations. The set of vectors drawn on land were from an Acoustic Doppler Current Profiler deployment off Sandwich Point. Current vectors at 2, 3, 4, 5, 10, 15, 20, 25 and 30 m are displayed.

A physical oceanographic program was conducted in Ship Harbour in the late 1990s; a number of temperature recorders and one acoustic Doppler current profiler (ADCP), located in a deep hole just inside the harbour's mouth, were deployed. The monthly mean freshwater inflow in Ship Harbour varies from 33.4 m^3/s in April to 7.4 m^3/s in September, comparable to Halifax Harbour and about 75% of the St. Margarets Bay inflow. The ratio of freshwater inflow to inlet volume for Ship Harbour is about 40 times greater than the ratio for Halifax Harbour and about 80 times greater than St. Margarets Bay. In addition, the mouth of Ship Harbour is narrower than the mouths of the other two inlets; the cross-sectional areas of the mouth of Halifax Harbour and St. Margarets Bay are 55 and 75 times greater than that of Ship Harbour. Thus we would expect that the estuarine circulation in Ship Harbour would be stronger than in the other two inlets. However, the seasonal mean current vectors do not reflect this conclusion (Figure 6-8). While the mid-depth (12 m) and deep (20 m) currents are into the harbour as expected, the near surface flow (3 m) is almost perpendicular to the local coastline with a small component into the inlet. The flow at shallower depths could be out of the inlet, however, the ADCP could not measure the current at depths less than 3 m.

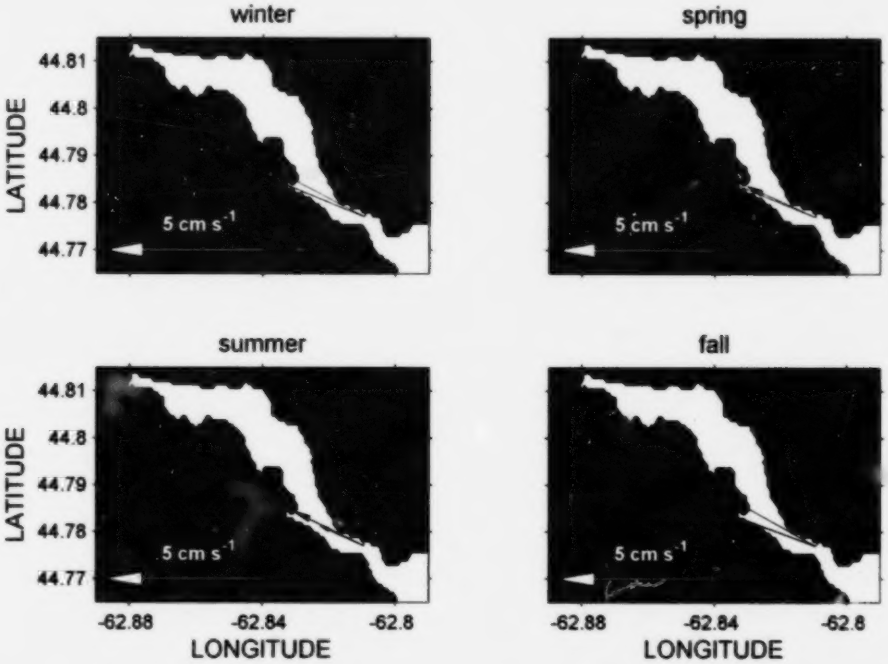


Figure 6-8: Seasonal mean currents for Ship Harbour. Black arrows are for observations from 3 m, red for 12 m, blue for 20 m.

Temperature and Salinity

The long-term temperature, salinity and sigma-t averages in the range 0-100 m for the region outside the coastal headlands in areas 4-6 are shown in Fig. 9. An extensive layer of cold water develops in the winter with temperatures less than 1°C. In spring and throughout the summer as heat exchange from the atmosphere to the ocean increases, a shallow warm layer forms with temperatures that exceed 15°C. During summer and fall, vertical diffusion and mixing deepen the warm layer. Figure 6-10 shows the monthly mean hydrographic properties and their statistics at 0, 20 and 50 m. The standard deviations are based on monthly mean values of each variable; the maximum and minimum values are based on individual observations. In summer, the difference between the minimum and maximum observed temperatures can reach ~15°C.

Wind forcing over the shelf and within the inlets can alter the temperature and salinity structure through mixing, upwelling and downwelling. In fact, the latter two processes are major contributors to the large differences between maximum and minimum property values (Figure 6-10). Winds from the southwest towards the northeast are most effective in areas 4-6 in generating coastal upwelling; winds in the opposite direction drive downwelling (Hachey 1935, 1937; Petrie et al. 1987). Given the distribution of temperature and salinity in summer (Figure 6-9), coastal upwelling will cause surface waters to move offshore and be replaced by colder, saltier waters from below. This process also causes extensive flushing of the waters of coastal inlets. The most striking recorded case of coastal upwelling on the shelf occurred in July 1984 (Petrie et al.1987)

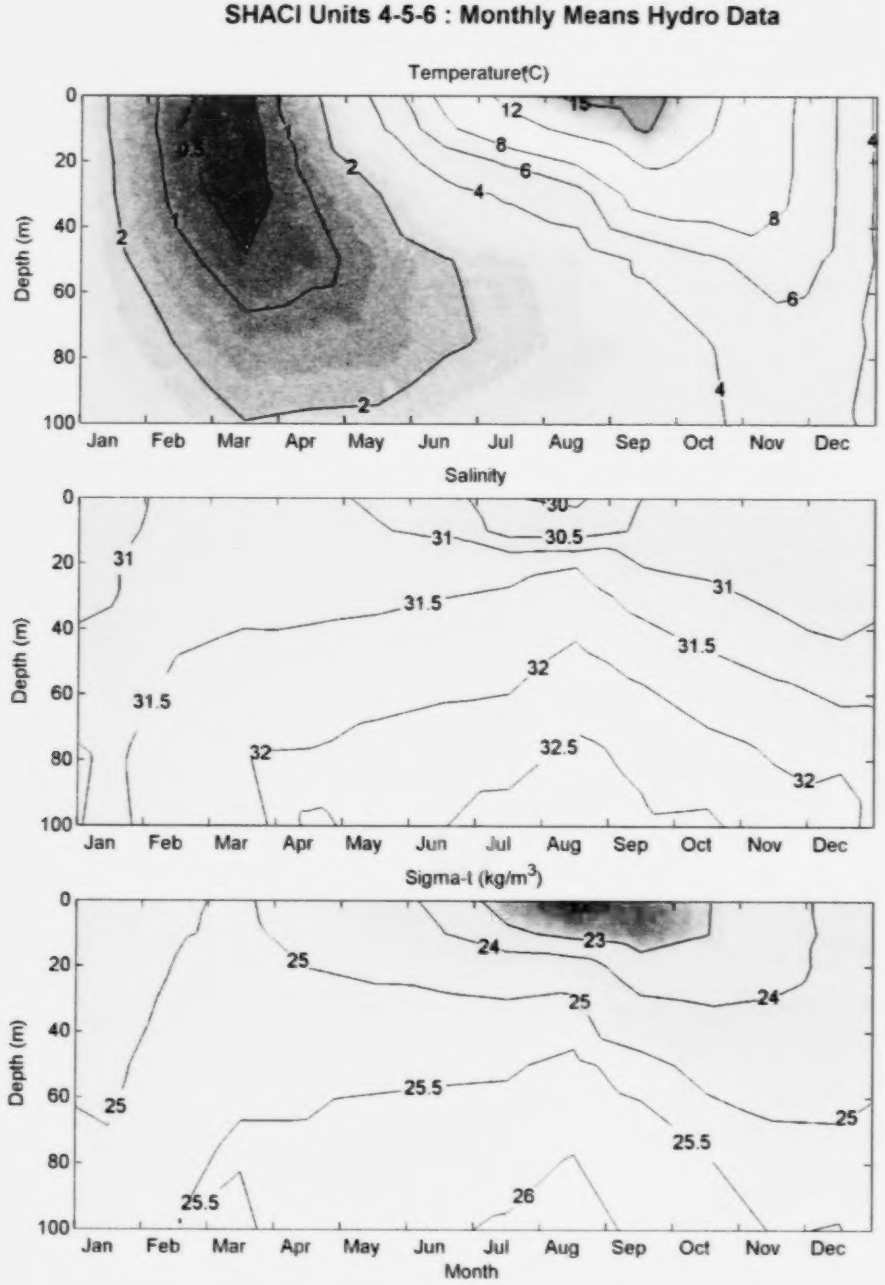

SHACI Units 4-5-6 : Monthly Means Hydro Data

Figure 6-9: Vertical structure of long-term monthly averaged temperature, salinity and sigma-t (density) for the shelf region of areas 4-6.

inlets. The most striking recorded case of coastal upwelling on the shelf occurred in July 1984 (Petrie et al.1987)

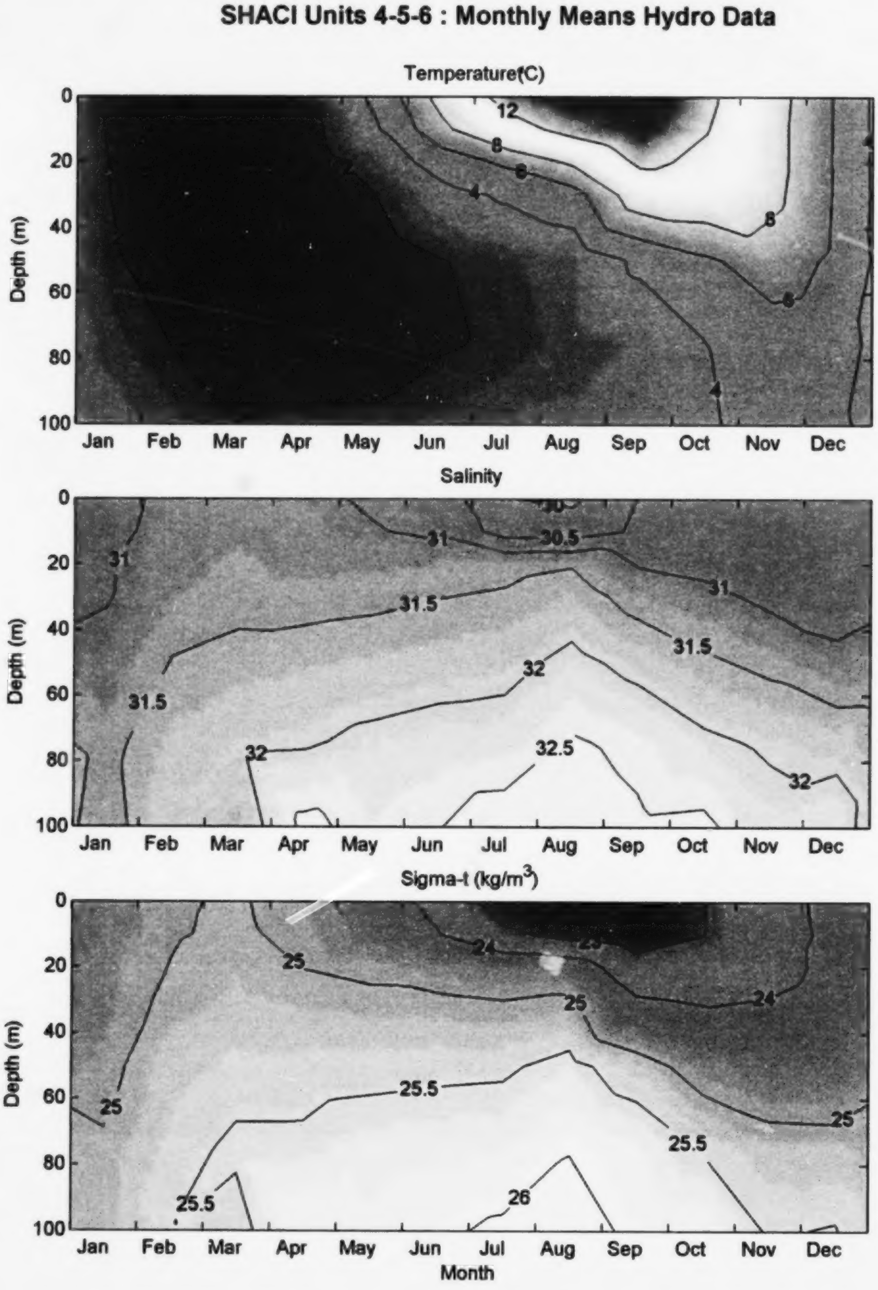


Figure 6-9: Vertical structure of long-term monthly averaged temperature, salinity and sigma-t (density) for the shelf region of areas 4-6.

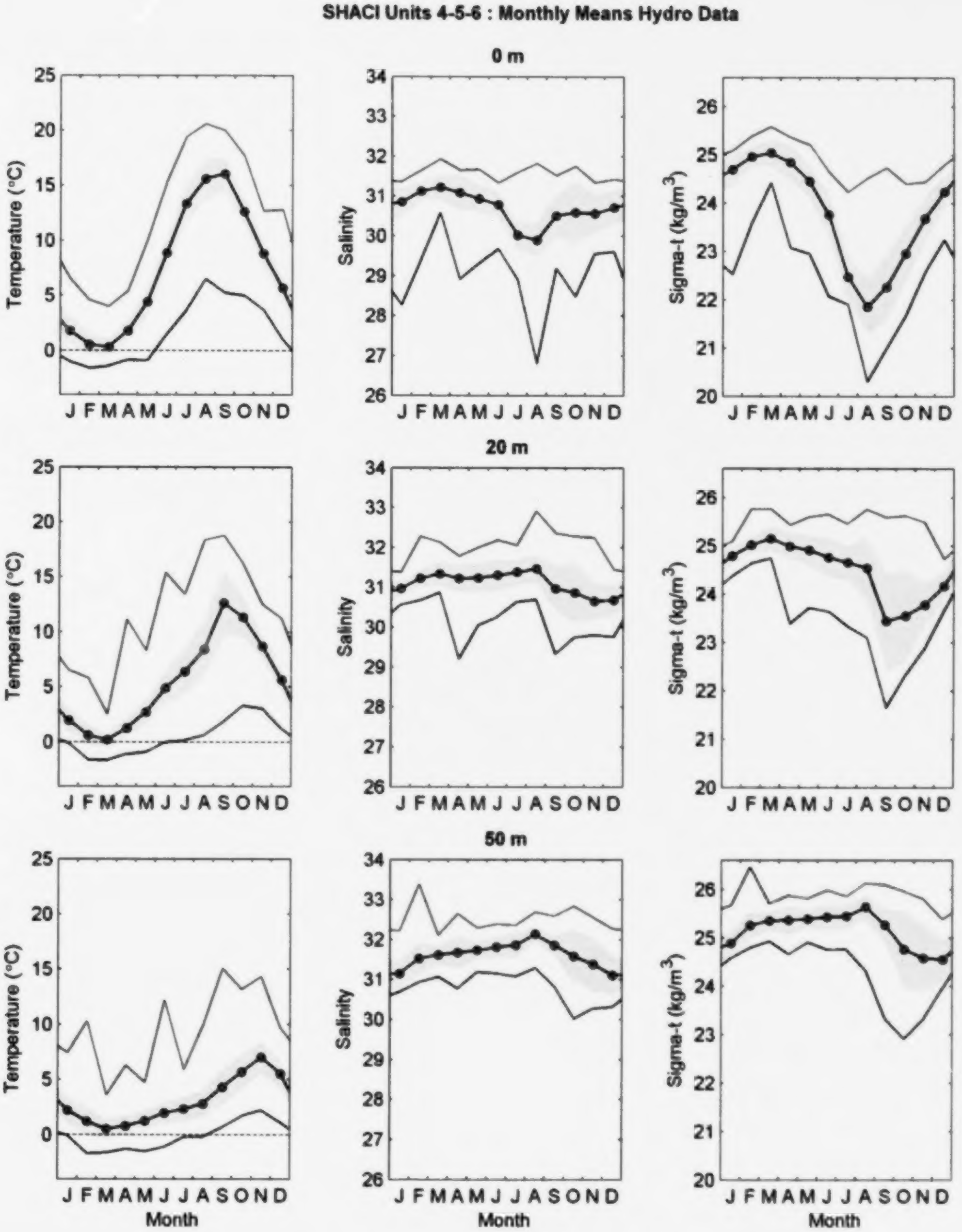


Figure 6-10: Average (black lines, dots), standard deviations (shaded areas), maxima (red lines) and minima (blue lines) of temperature, salinity and sigma-t.

1987). The wind had blown persistently from the southwest for about one month favouring upwelling. Figure 6-11 shows the sea surface temperature captured by satellite on July 25th, near the end of the period of upwelling favourable winds. A 50 km wide band of water with temperatures as low as 4°C was seen all along the coast and in the inlets. A time series of images indicated that development of this feature occurred sooner in the open shelf area than in the major inlets, e.g. St. Margarets Bay. Also evident are the large, regularly spaced plumes that project from the coastal zone to the edge of the shelf, about 200 km offshore. Coastal temperatures normally increase by about 4.1°C from June to July in the upper 10 m of the Scotian Shelf. In 1984, the increase was only 0.5°C, indicating the major impact of this upwelling event.

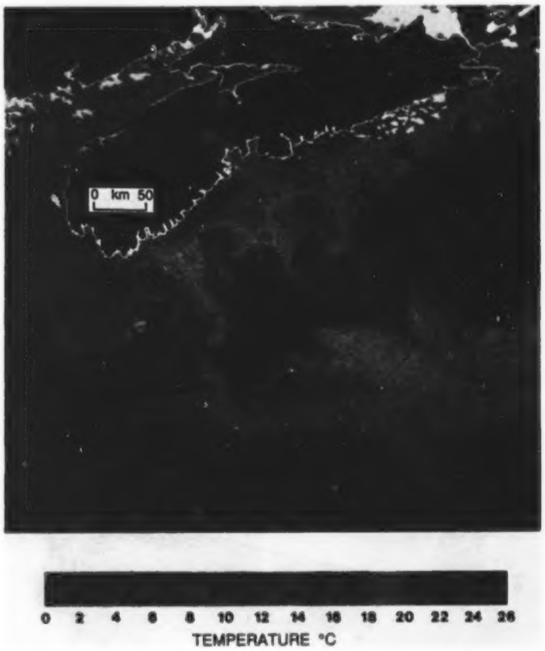


Figure 6-11: Sea surface temperature, July 25, 1984.

Tidal flushing also affects the hydrographic properties of the coastal inlets on the Scotian Shelf. Consider the water exchange caused by M2, the largest tidal constituent in this region. Between low and high water, 6.21 h for M2 , a layer of water about 1.2 m thick will come into the inlet (see Sea Level section below). It will mix with the ambient waters and, during the falling tide, carry some of these waters out onto the shelf. During the following rising tide, some new water will enter the inlet. Thus during every tidal cycle, some of the inlet's waters will be removed, some new water will be introduced. This process is known as tidal flushing. The shortest flushing time for an inlet would occur if, on every tidal exchange, only the original water in the inlet flowed out during the falling tide. Then the flushing time of the inlet can be derived by comparing its average depth, Zave, to the tidal range, ς_{range}. A rough estimate of the flushing time, F_T, for M2 alone is then $F_T=(Zave/\varsigma_{range})*T$, where T is the M2 tidal period. For Halifax Harbour, this would be about 8.4 days. In fact, the flushing time due to the M2 tide would be much longer than this. Gregory et al. (1993) have estimated flushing times using a different, but still approximate, technique for inlets in the entire Maritimes region.

In summary, flushing of inlets in areas 4-6 can be episodic events that may arise from a major storm; there is evidence of such events occurring in Bedford Basin where Krauel (1969) observed major, short-term fluctuations of nutrients and oxygen. Tidal flushing would be characterized as a steady, more gradual process.

The annual cycle of temperature in the inlets of units 4-6 can differ from that on the adjacent Scotian Shelf because of shallower depths and sheltering effects arising from the geography of the bays. The annual cycle of mean monthly temperatures, standard deviations based on monthly averages and extreme temperatures based on individual observations for St. Margarets Bay (0-5 m), Fink Cove (0-10 m), Halifax Harbour (0-5 m) and Ship Harbour (0-5 m) are quite similar (Figure 6-12(a)). All sites feature minimum monthly temperatures in February-March and maximum values in August-September. Variability is least in the winter months and greatest during summer.

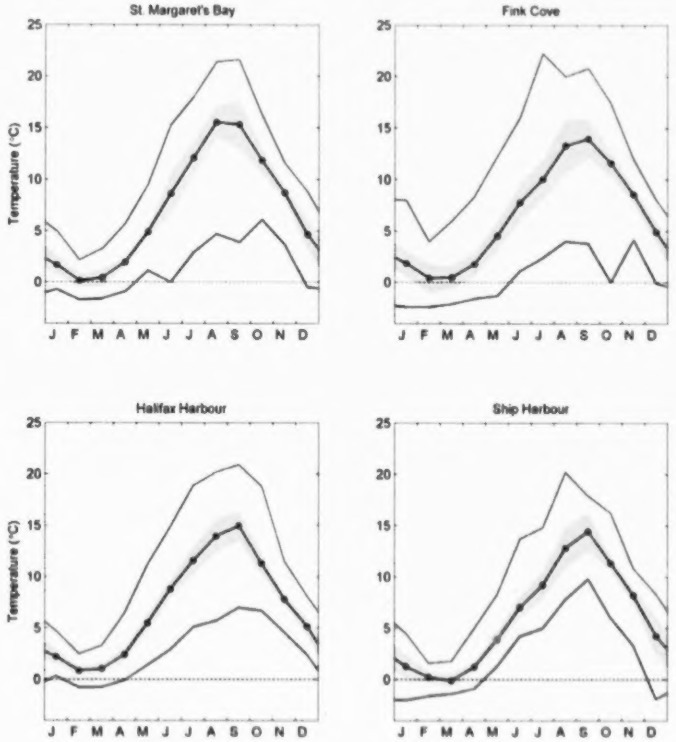


Figure 6-12(a). Average (black lines, dots), standard deviations (shaded areas), maxima (red lines) and minima (blue lines) of temperature.

The annual sea surface temperature anomalies from Halifax Harbour 1926-2004 show considerable interannual variability. The annual anomalies are the averages of monthly anomalies for each year; the reference period for the monthly means is 1971-2000. The maximum difference between the coldest and warmest years is about 4°C. Extended periods of above and below normal temperatures are apparent. Colder than normal conditions have prevailed over the last 20 years.

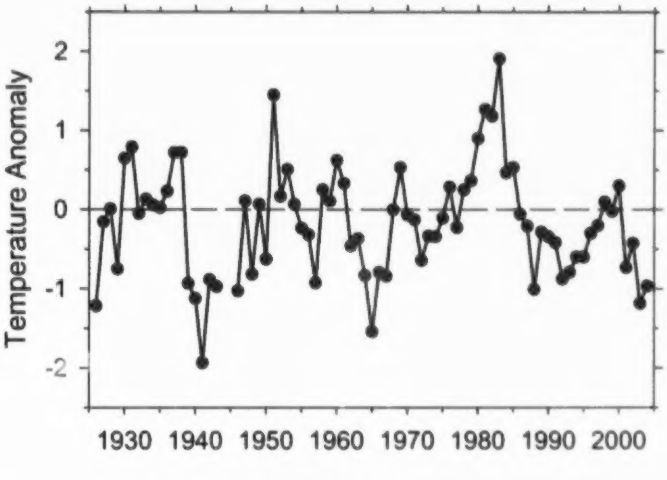


Figure 6-12(b). Annual, sea surface temperature anomalies for Halifax Harbour 1926-2004.

Sea Level

Sea level observations have been collected in Halifax Harbour continuously since 1920. These data are referenced to a common benchmark fixed on land by the Canadian Hydrographic Service. Some measurements were also made in the 1850s, 1860s (reference benchmark uncertain) and 1890s (referenced to the current benchmark). These observations are representative of sea level variations throughout areas 4-6. Tides, particularly the M2 (period 12.42 h), S2 (12 h), N2 (12.63 h), K1 (23.93) and O1 (25.82 h), are major contributors to sea level variability in the region. Atmospheric pressure variations, local wind and sea level variations that propagate into the area from other regions make important contributions to sea level variability. In addition to these higher frequency components, relative sea level at Halifax has risen quite steadily in the last 100 years. Relative sea level is the combination of absolute sea level change (the volume of water or circulation in the ocean is changing) and sinking of the Halifax region as a result of post-glacial rebound.

Tides

Table 6-1 below shows the major tidal constituents based on Halifax sea level data from 2001. Though there is interannual variability of the constituents, the magnitude of the variations is generally only a couple of centimetres for the larger components. The Z0 constituent represents the mean sea level above the Halifax benchmark. The remaining constituents are ordered by decreasing amplitude; only constituents with an amplitude greater than 1 cm are listed. The M2 constituent is by far the largest at 62.5 cm, about 4 times the amplitude of the next largest, N2.

Table 6-1: Tidal constants for Halifax based on 2001 data

Constituent	Period (h)	Amplitude (cm)	Phase (AST)
Z0	0.00	103.4	0.0
M2	12.42	62.5	232.3
N2	12.66	14.8	211.7
S2	12.00	13.1	260.0
K1	23.93	10.8	61.0
O1	25.82	4.7	39.6
M4	6.21	4.0	36.6
K2	11.97	3.8	255.8
P1	24.07	3.6	55.7
NU2	12.63	3.2	215.0
MM	661.30	2.7	197.3
MF	327.85	2.5	270.4
L2	12.19	2.5	253.5
MSM	763.48	2.4	287.5
MU2	12.87	2.2	220.8
2N2	12.91	2.0	197.1
MS4	6.10	1.9	158.3
MN4	6.27	1.9	339.4
MSF	354.36	1.7	201.4
J1	23.10	1.0	85.5
Q1	26.87	1.0	87.2

Long-term Trend

Figure 6-13 shows the monthly sea level (grey line) and the annual average sea level (black) from Halifax from 1970 to 2004. A linear trend (red) fitted to the data indicates that, on average, Halifax relative sea level has been rising at the rate of about 32.5 cm/century. We emphasize that this is a sea level rise relative to the fixed benchmark and is made up of the change caused by true sea level variation in the ocean and a component due to the Halifax region (i.e. the benchmark) sinking in response to post-glacial rebound.

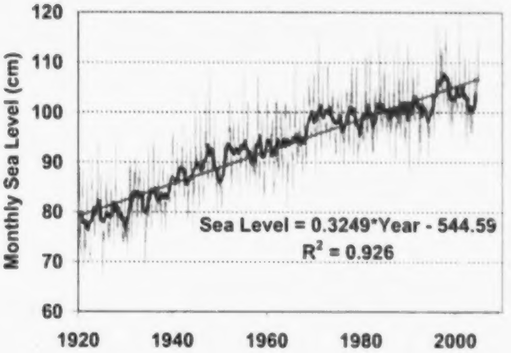


Figure 6-13: Monthly (grey), annual (black) and linear trend (red) of sea level at Halifax.

Distribution of sea level about the long-term mean and trend

A potentially useful data product is the distribution of sea level variations about the long-term mean and trend (Figure 6-14). The mean and trend determined in the last section were removed from the data and the histogram and cumulative distribution of the residuals determined in 10 cm bins. The results could be used to approximate future variations about a new and potentially higher value of mean sea level. The analysis indicates that there were four points between 140 and 150 cm below mean sea level (lowest was 144.7 cm) and one (181.6 cm) between 180 and 190 cm above mean sea level. The cumulative distribution is determined by summing the number of points in each bin, in this case starting with the bin with the lowest values, -140 cm below mean sea level (Figure 6-15). The assumption is that the higher sea levels, which may cause flooding, are of

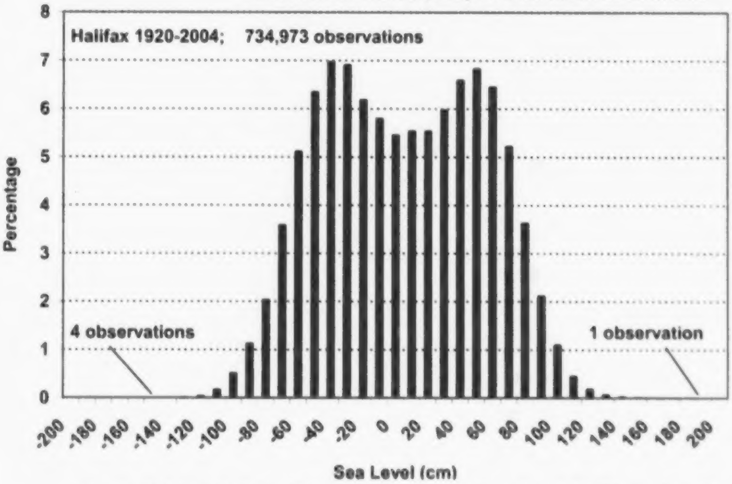


Figure 6-14: Distribution of hourly sea levels at Halifax about the long-term mean and trend.

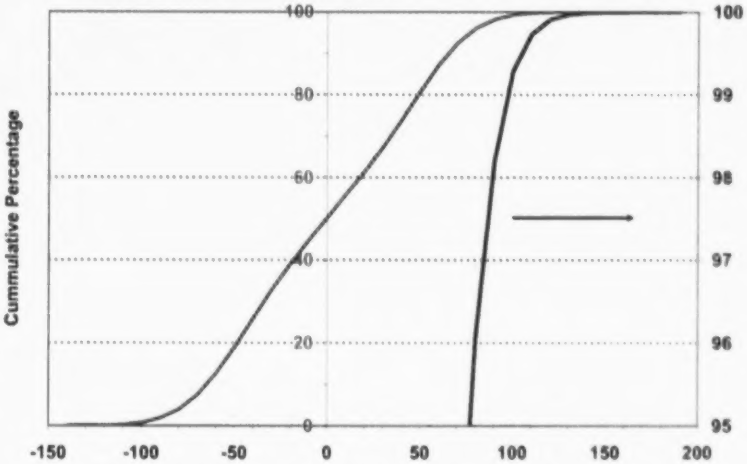


Figure 6-15. Cumulative distribution of Halifax sea level about the long-term mean and trend. The red curve shows the overall distribution: the blue curve shows the upper 5% of the distribution.

greater interest than the extreme lower levels. About 92% (99.5%) of the values overall are within 80 cm (110 cm) of mean sea level.

The co-occurrence of extreme sea levels, particularly high water, and other variables such as waves and ice can act to produce larger effects than one variable would have acting alone. The superposition of high tides with a storm surge and extreme wave conditions as was the case for hurricane Juan can lead to extensive damage in the coastal zone.

Waves

Wave statistics for the coastal zone off Halifax are based largely on the observations made by a wave rider buoy moored off Chebucto Head since 1970 (MacLaren-Plansearch 1991). The monthly means, standard deviations (shaded), medians, upper 95% and maximum significant wave heights are based on 49367 wave spectra (Figure 6-16). A strong annual cycle is apparent in all of the variables with the largest values in winter and the smallest in summer. The distribution of significant wave height and peak period shows a concentration between 0.5-1 m, and 8-9 sec (Figure 6-17). The distribution of significant wave height and wave direction has a broad peak centered about 240° and 1-2 m significant wave height (Figure 6-18).

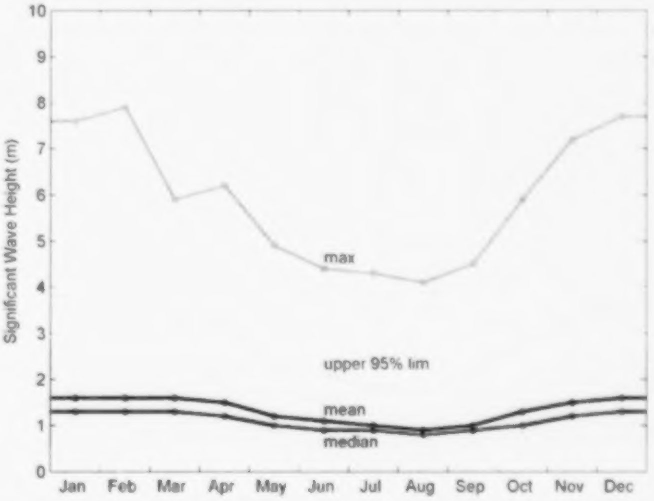


Figure 6-16. Monthly significant wave height statistics for the shelf region of SHACI areas 4-6 (MacLaren-Plansearch 1991).

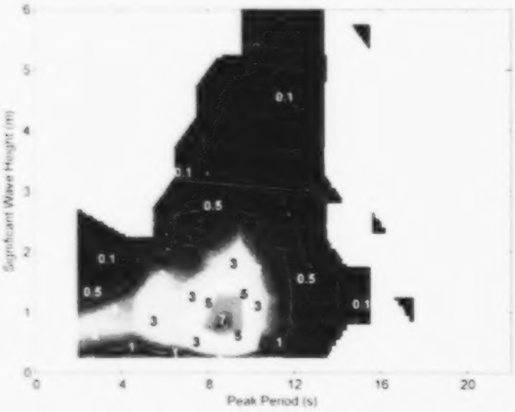


Figure 6-17: Annual significant wave height-peak period percentage occurrence distribution for the shelf region of SHACI areas 4-6 (MacLaren-Plansearch 1991).

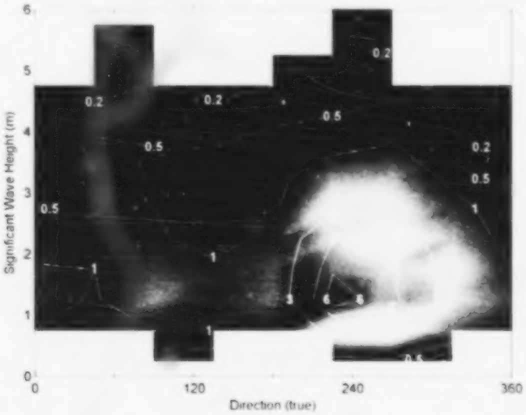


Figure 6-18: Annual significant wave height-direction percentage occurrence distribution for the shelf region of SHACI areas 4-6 (MacLaren-Plansearch 1991).

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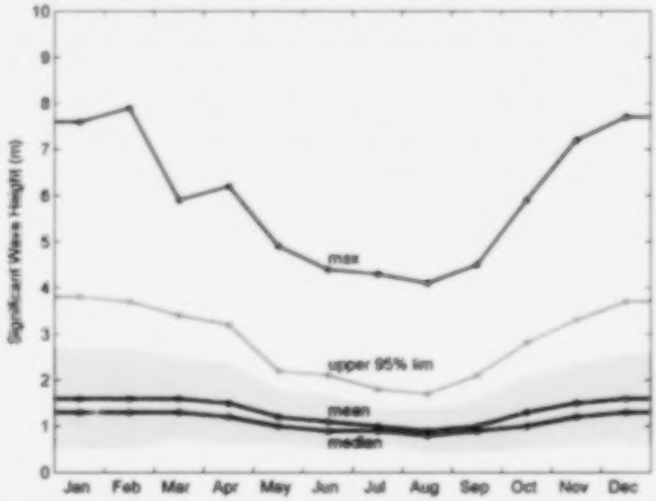
Waves



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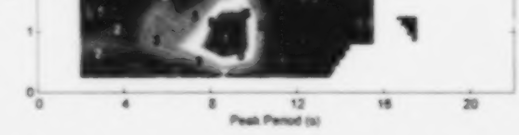

Figure 6-17: Annual significant wave height-peak period percentage occurrence distribution for the shelf region of SHACI areas 4-6 (MacLaren-Plansearch 1991).

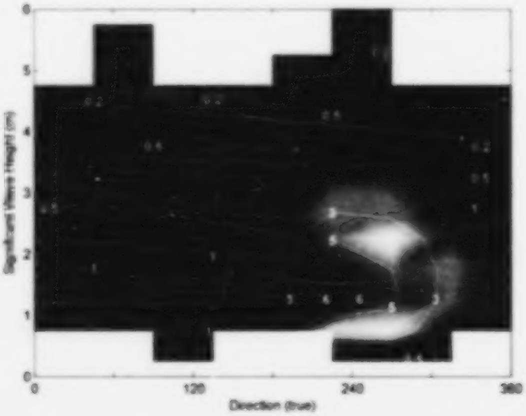

Figure 6-18: Annual significant wave height-direction percentage occurrence distribution for the shelf region of SHACI areas 4-6 (MacLaren-Plansearch 1991).

Wind

The wind speed and direction not only strongly influence the currents in the inshore area but also can directly affect the operations that can be carried out. Meteorological statistics are usually revised every 10 years and are based on the latest 30 year period beginning with a one. Hence, the current long-term statistics are compiled for the period 1971-2000. We present two sets of statistics: one using the Shearwater observations and representative of the coastal zone; the second based on the Sable Island data and more representative of the shelf region of areas 4-6.

The monthly distributions of wind speed and direction (direction from which the wind is blowing) for Shearwater and Sable Island are shown in Figures 6-19 and 6-20. The annual mean wind speed for Shearwater is 15 km/h, varying from a monthly high of 18 km/h in January to a low of 11 km/h in August (Figure 6-21). The maximum hourly wind speed in the 1971-2000 period was 87 km/h. The distribution of wind direction varies considerably throughout the year, for example from predominantly from the west in January, to an approximate even distribution in April, to the south in June and to the west in October. Note the large number of points in the 0-10° bin is because all zero speed winds are recorded as from the north.

Sable Island winds are stronger and generally have more-narrowly defined direction distributions than Shearwater. The annual mean wind speed for Sable is 25 km/h and varies from a high of 31.5 km/h in January to a low of 17.5 km/h in August (Figure 6-21). The maximum hourly wind speed in the 1971-2000 period was 130 km/h. The distribution of wind direction varies less throughout the year than the Shearwater observations. Fall and winter winds are predominantly from the west and spring and summer winds from the southwest.

Ice

Ice from the Gulf of St. Lawrence carried by the Nova Scotia Current provides most of the ice cover in the shelf region of areas 4-6. The average cover, dominated by the contributions from two years of the series, is about 4400 km^2 (Figure 6-22). The median ice cover on the other hand, is only 600 km^2. In 13 of the 42 years of record, i.e. about 30% of the time, there was no ice cover. The largest annual ice cover, 74000 km^2, occurred in 2003.

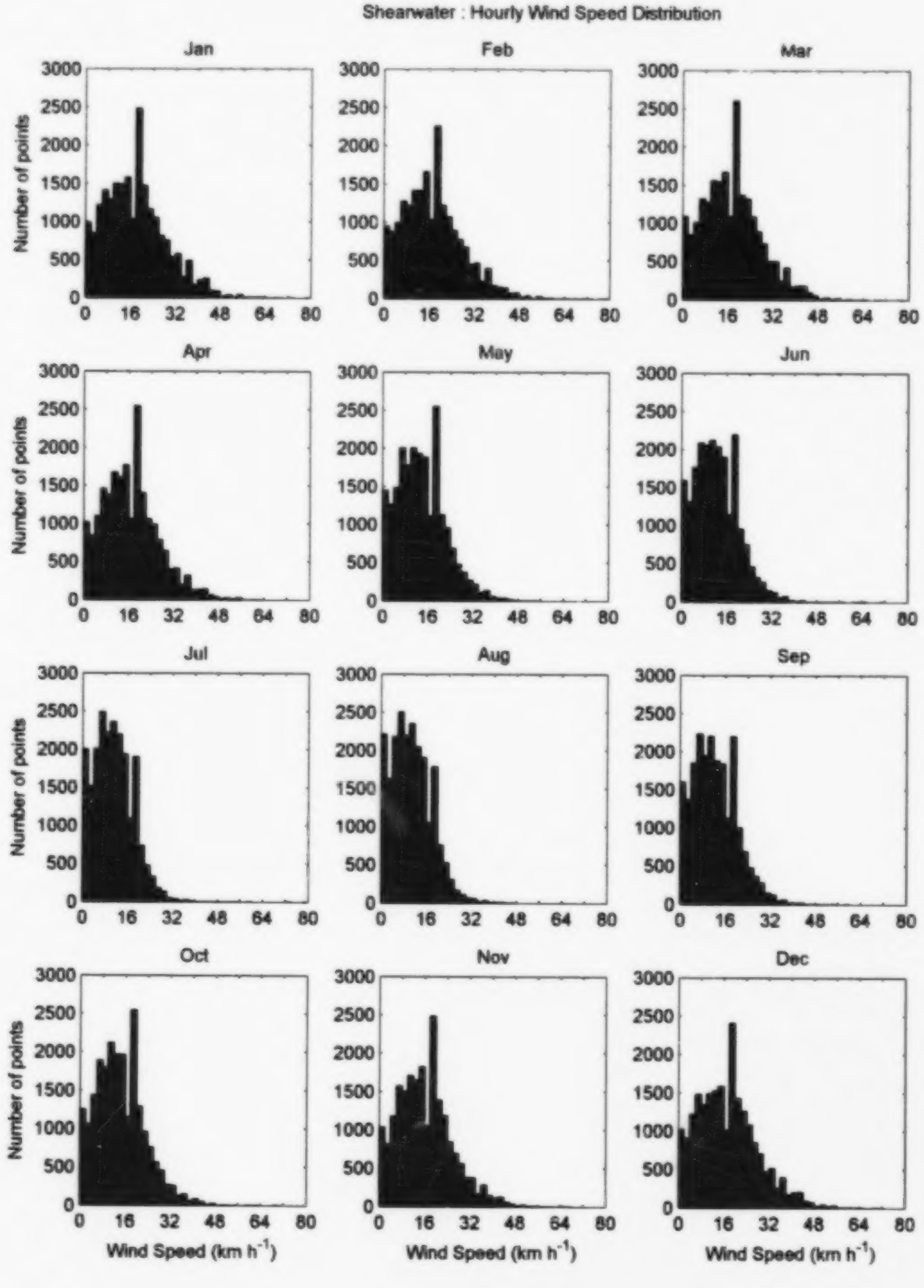

Figure 6-19: Distribution of hourly wind speeds at Shearwater 1971-2000.

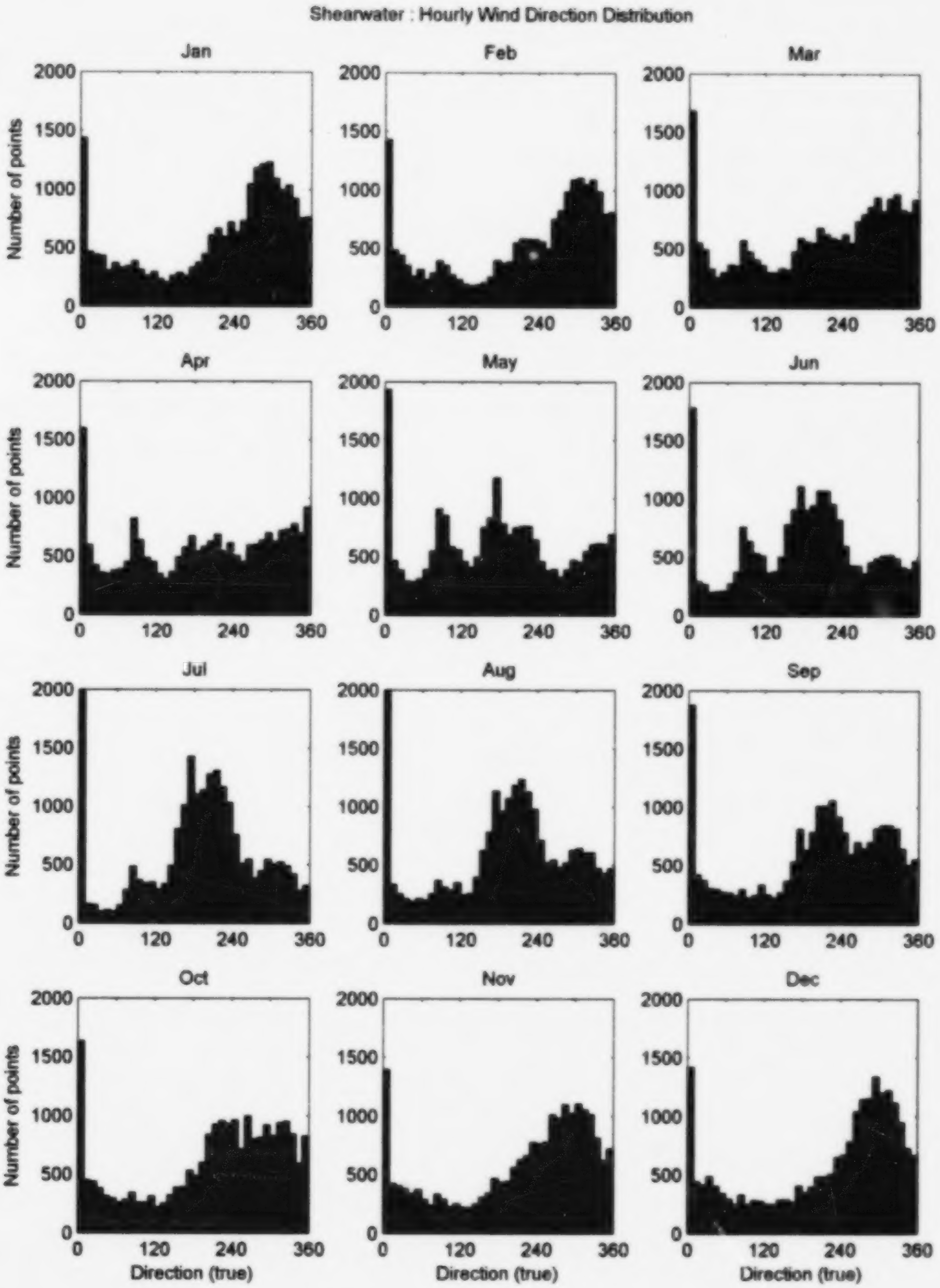

Figure 6-19 continued: Distribution of hourly wind directions at Shearwater 1971-2000.

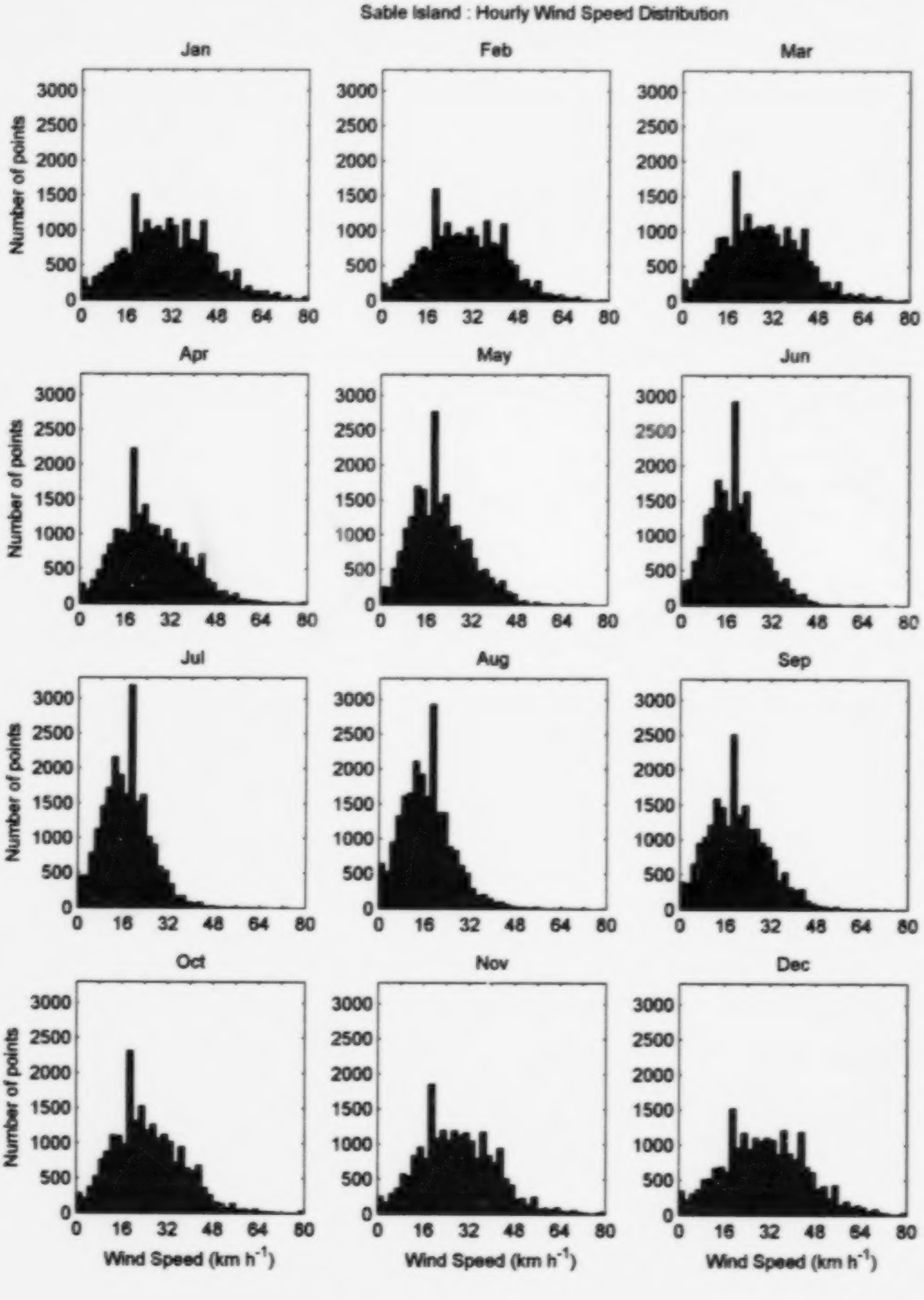

Figure 6-20: Distribution of hourly wind speeds at Sable Island 1971-2000.

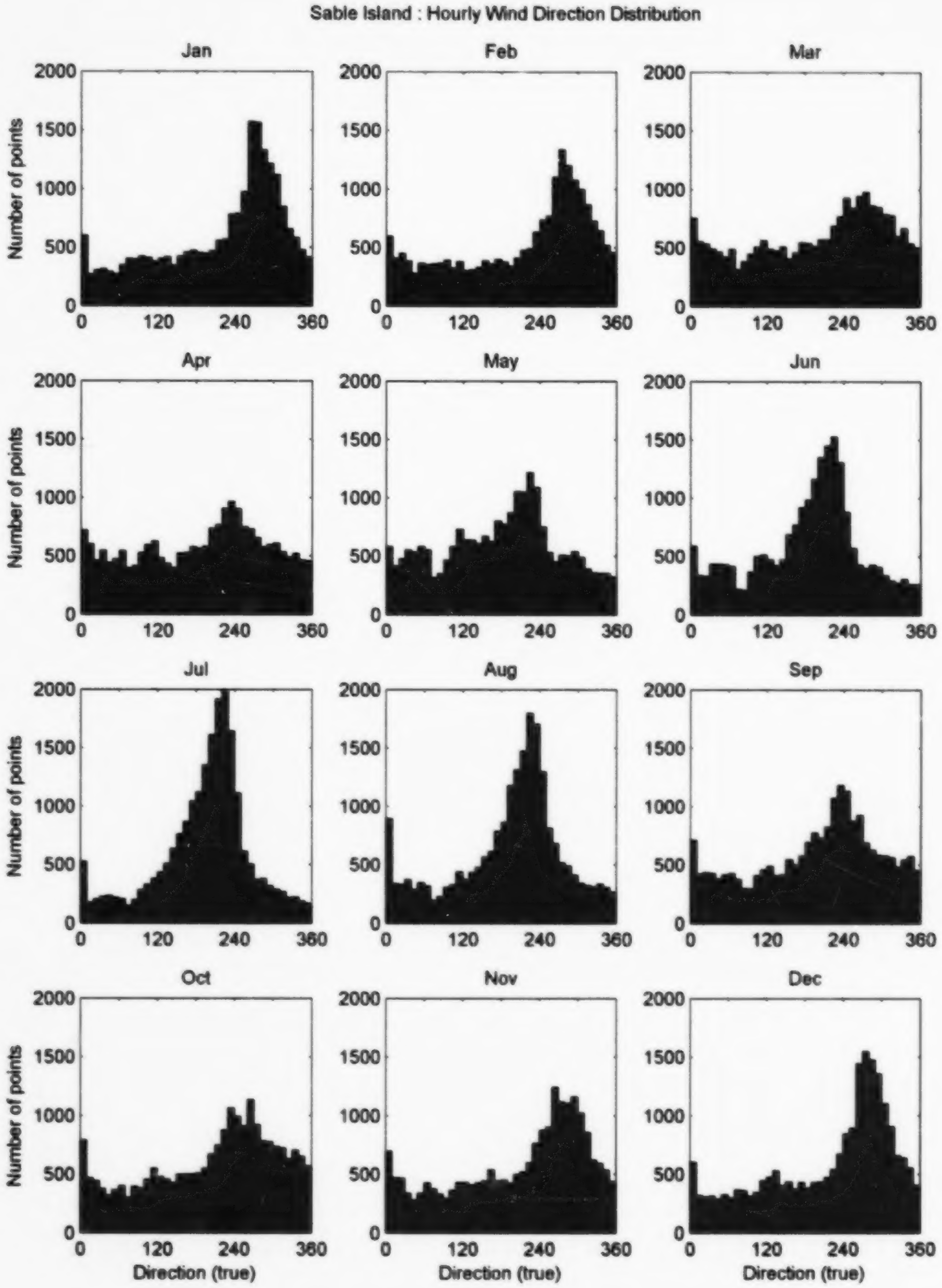

Figure 6-20 continued: Distribution of hourly wind directions at Sable Island 1971-2000.

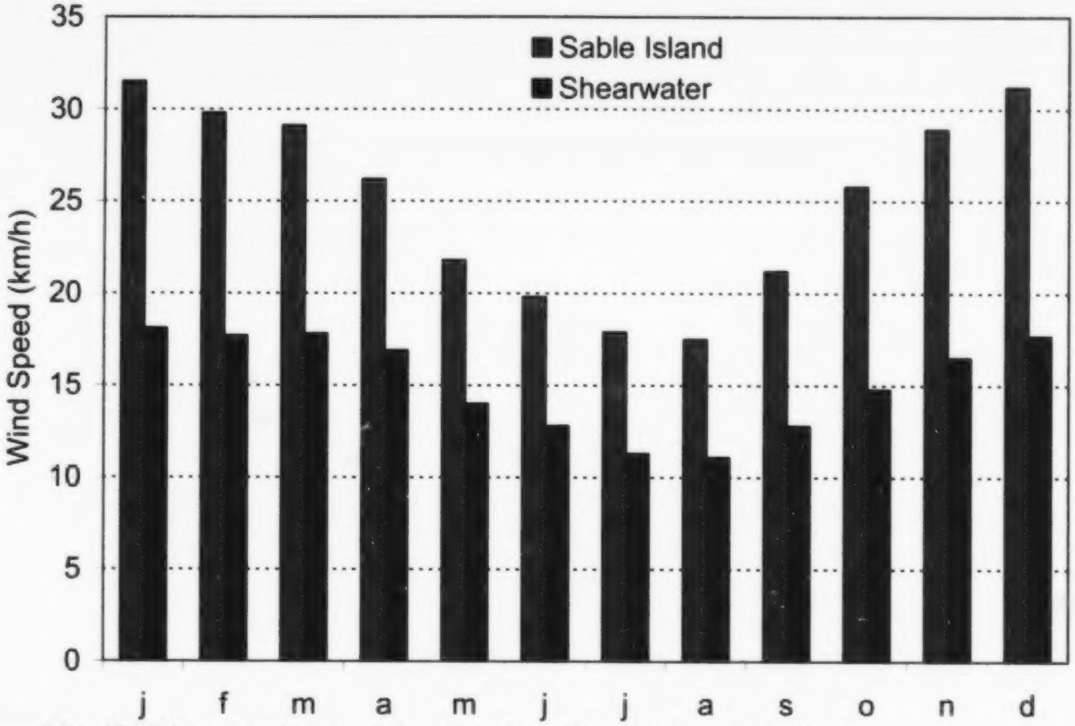

Figure 6-21: Monthly average hourly winds speeds from Shearwater and Sable Island.

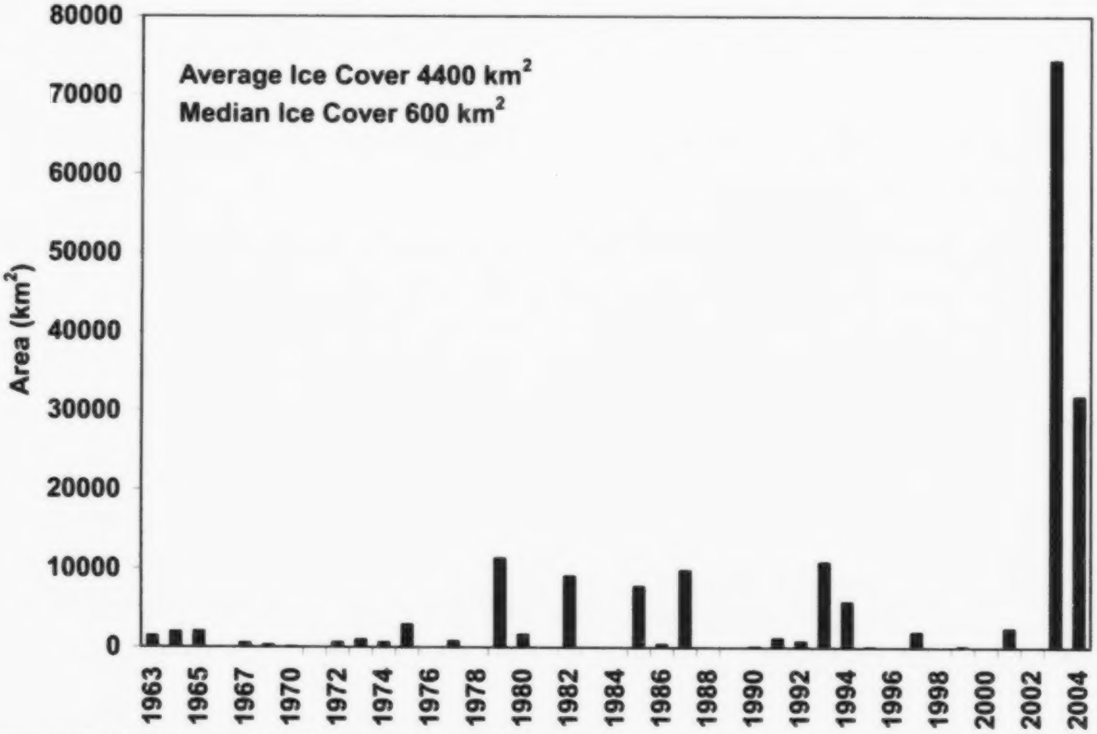

Figure 6-22: Time series of shelf ice cover for SHACI areas 4-6.

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7 - Coastal wetlands

There is no single, universally accepted definition for wetlands. Consequently, some names of wetland types are used interchangeably, whereas some wet areas may not be considered wetlands by certain individuals or organizations. This is largely due to the diversity of wetlands, the field of interest and objectives of the various users and, in some cases, the difficulties of distinguishing wet from dry environments (Mitsch and Gosselink 1986, NWWG 1988). In general terms, wetlands are a group of lands where saturation with water is the principal factor influencing the nature of soil development, the types of plant and animal communities living in the soil, on its surface, or in the water, and the various kinds of biological activities that occur there (Etherington 1983, Mitsch and Gosselink 1986, NWWG 1988).

The Maritime Wetland Inventory identified and classified freshwater and coastal wetlands (Hanson and Calkins 1996). The summary of Nova Scotia's wetlands suggests there are 35 331 wetlands, comprising 449 045 ha (Hanson and Calkins 1996) (Table 7-1). Of these, 2003 are coastal wetlands covering 225 615 ha and 33 328 are freshwater wetlands comprising 223 427 ha. Coastal wetlands occur in all counties in Nova Scotia. Estuarine flats are the most extensive type of coastal wetlands with over 205 488 ha in the province.

Table 7-1: Summary of Nova Scotia's freshwater and coastal wetlands (Hanson and Calkins 1996)

Type of wetland	No. of Wetlands	Area (ha)
Freshwater		
Open water	2255	15 809
Deep marsh	329	4048
Shallow marsh	98	423
Seasonally flooded flat	124	3586
Meadow	1774	11 410
Shrub swamp	7030	28 982
Wooded swamp	125	542
Bog	21 693	158 630
Coastal		
Salt marsh	1166	12 442
Estuarine flats	444	205 488

Of the freshwater wetlands in Nova Scotia, bogs are the most numerous and extensive, followed by the shrub swamps (Hanson and Calkins 1996). The seasonally flooded flats and wooded swamps that occur in the province are not extensive. Deep marshes, shallow marshes, flooded flats and wooded swamps have an uneven distribution in Nova Scotia, occurring infrequently or not at all in some counties.

Halifax County, which contains all of Unit 5 and the majority of Units 4 and 6, has the most wetlands of any county in the province (Table 7-2), however other counties contain more wetland area (Hanson and Calkins 1996). Bogs are the most numerous and extensive type of freshwater wetland in the county. Of the coastal wetlands, estuarine flats comprise the largest area. Some of the most extensive coastal wetlands in Halifax County, most of which occur in Unit 5, are shown in Figures 7-1 to 7-7.

Table 7-2: Summary of freshwater and coastal wetlands in Halifax County (Hanson and Calkins 1996)

Type of wetland	No. of Wetlands	Area (ha)
Freshwater		
Open water	370	1424
Deep marsh	35	482
Shallow marsh	37	49
Seasonally flooded flat	10	146
Meadow	63	825
Shrub swamp	469	2196
Wooded swamp	3	7
Bog	4896	16 484
Coastal		
Salt marsh	119	881
Estuarine flats	105	13 293
Saline ponds	31	564

The summary of Nova Scotia's wetlands outlined above did not include freshwater fens, marine flats or eelgrass beds. In this chapter, the following coastal wetlands in Units 4, 5, and 6 will be considered: salt marshes, estuarine flats, marine flats, eelgrass beds, coastal saline ponds, bogs and fens.

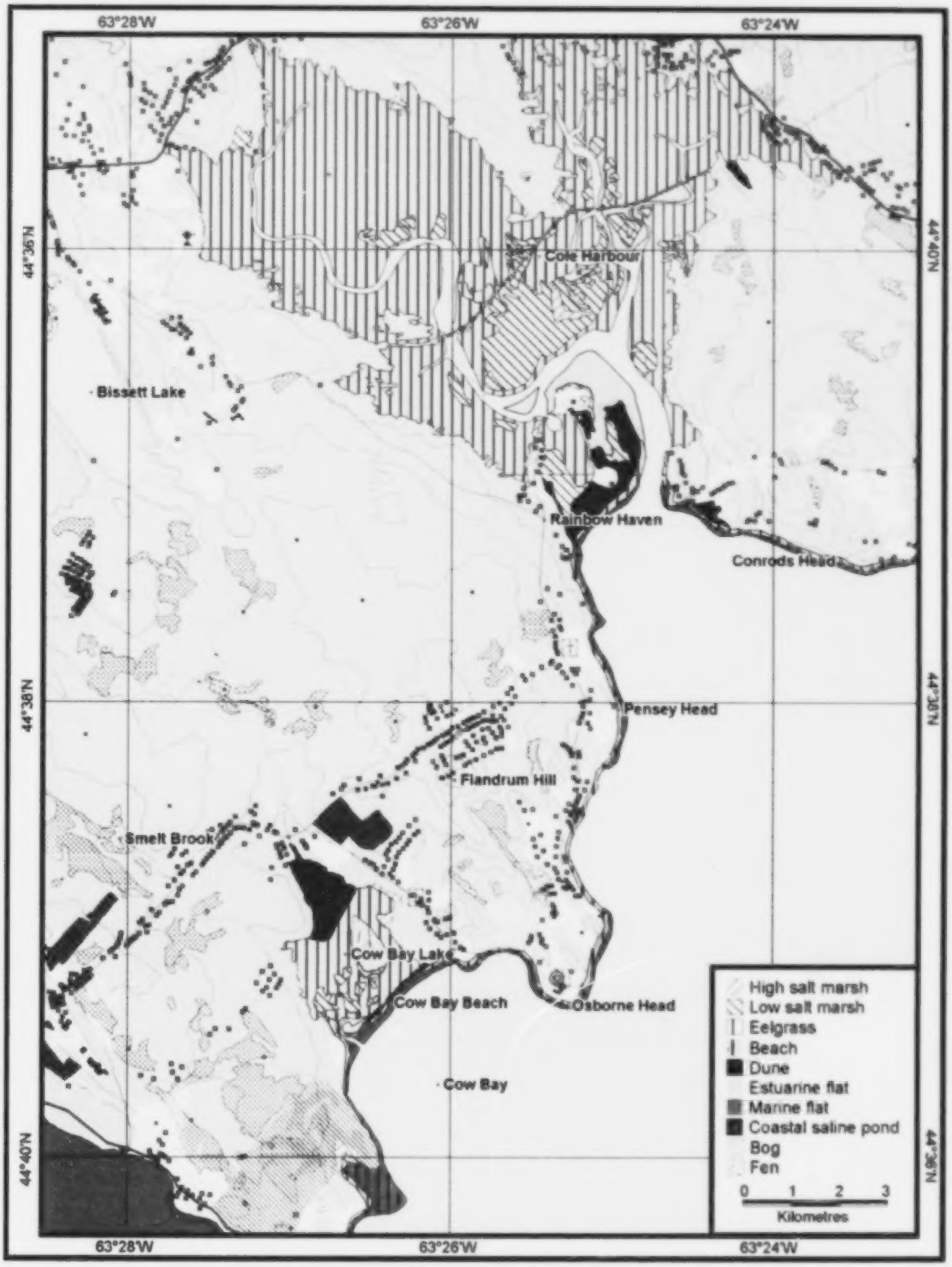

Figure 7-1: Cole Harbour area (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

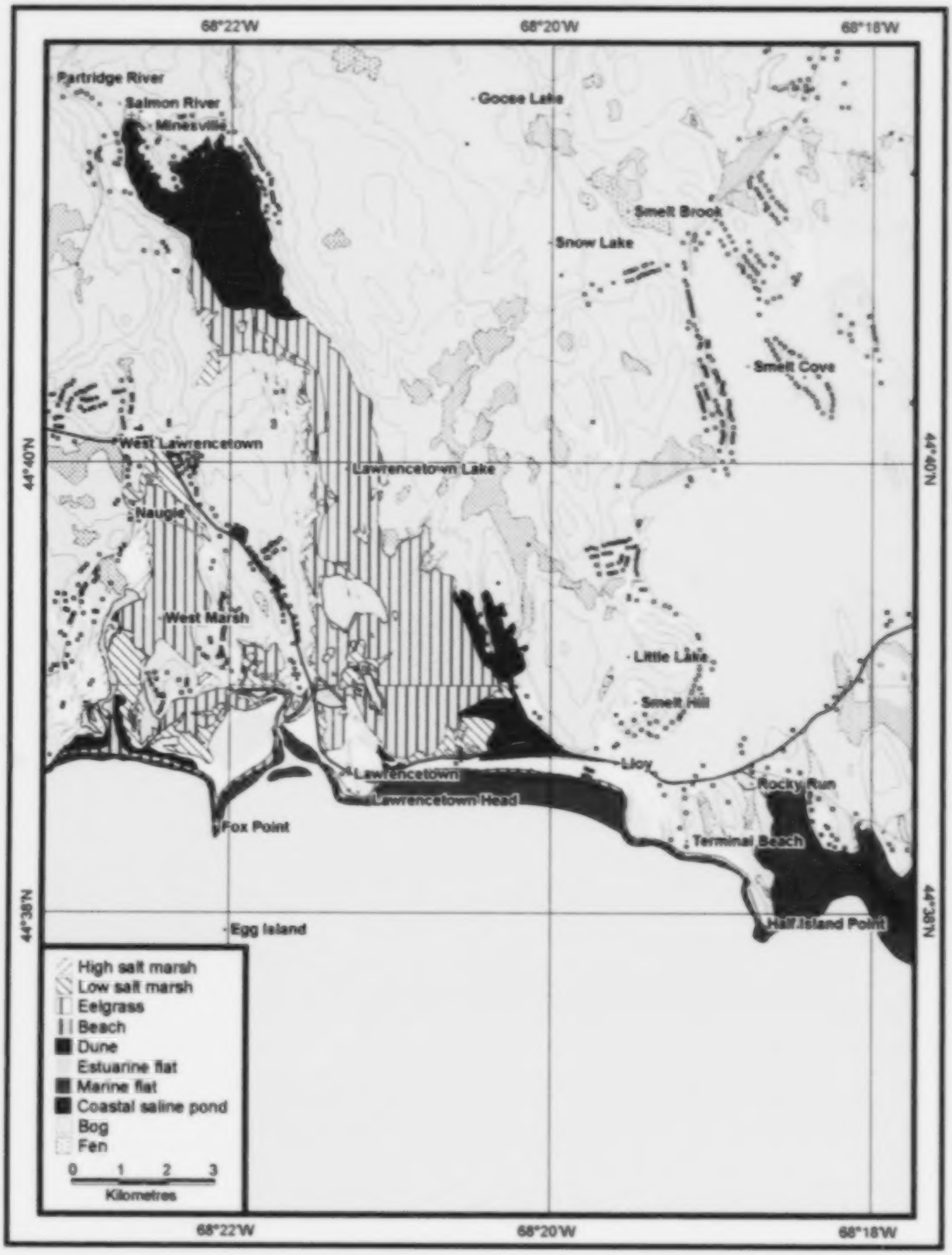

Figure 7-2: West Marsh and Lawrencetown area (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

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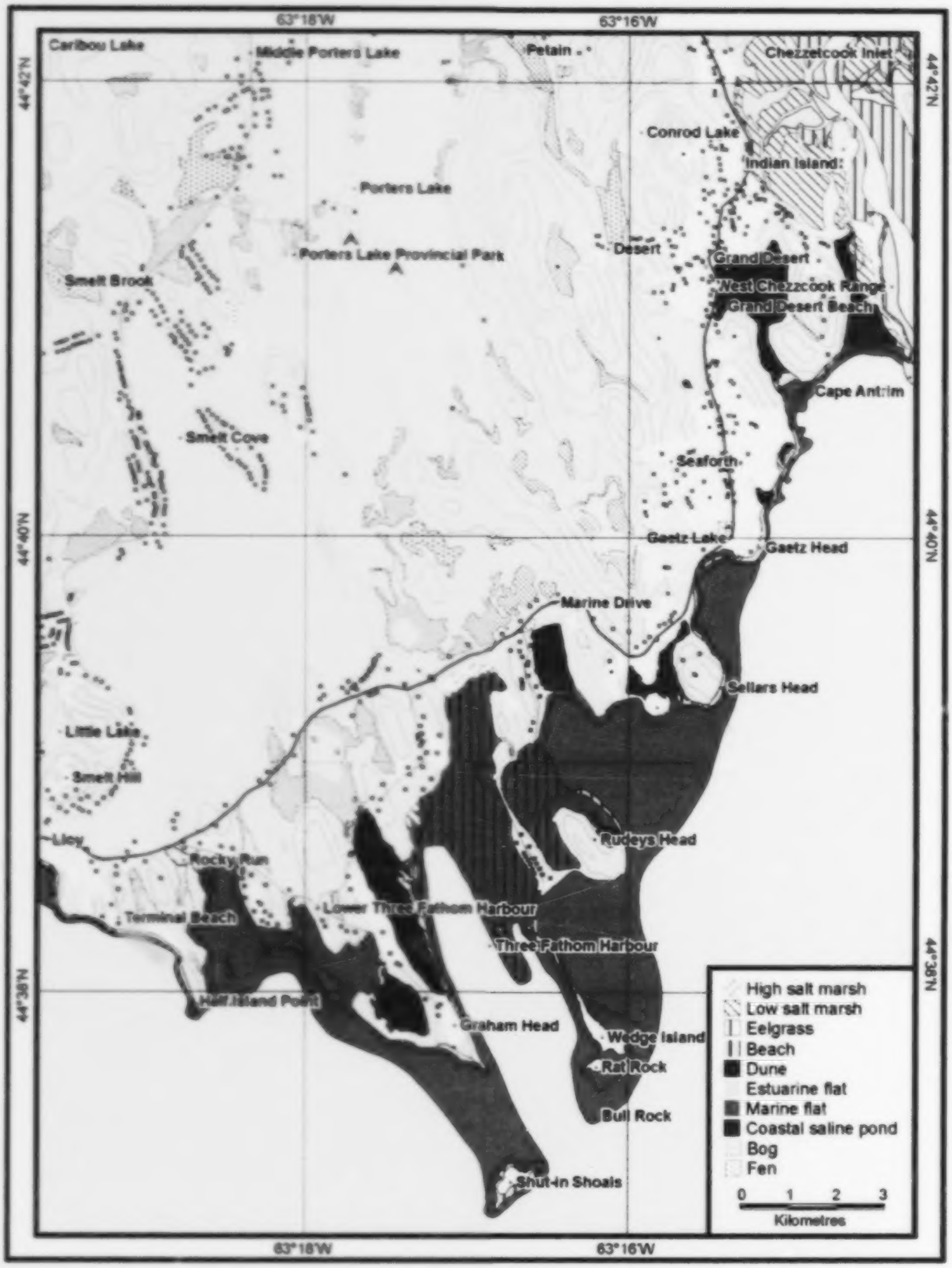

Figure 7-3: Three Fathom Harbour area (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

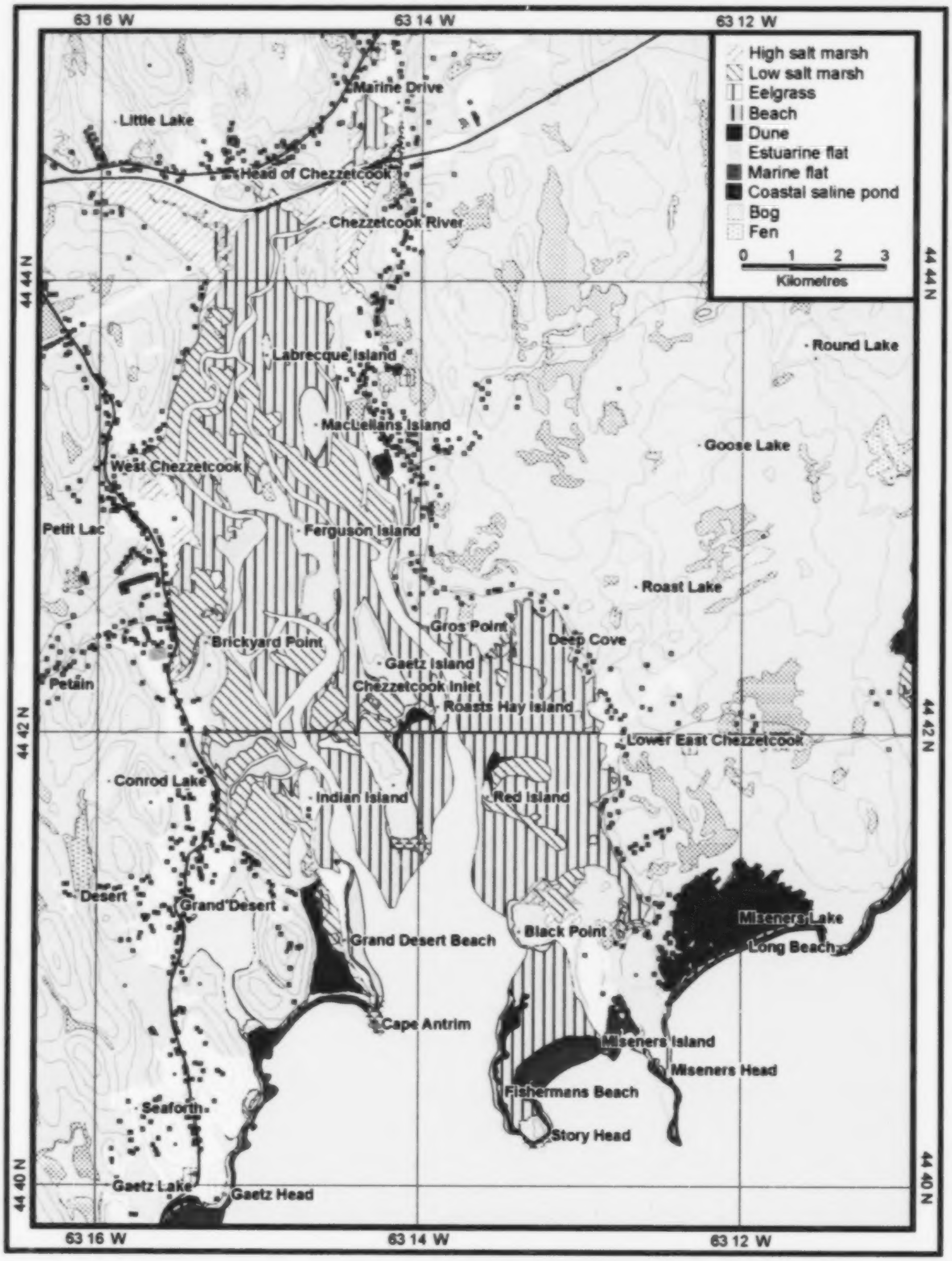

Figure 7-4: Chezzetcook Inlet area (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

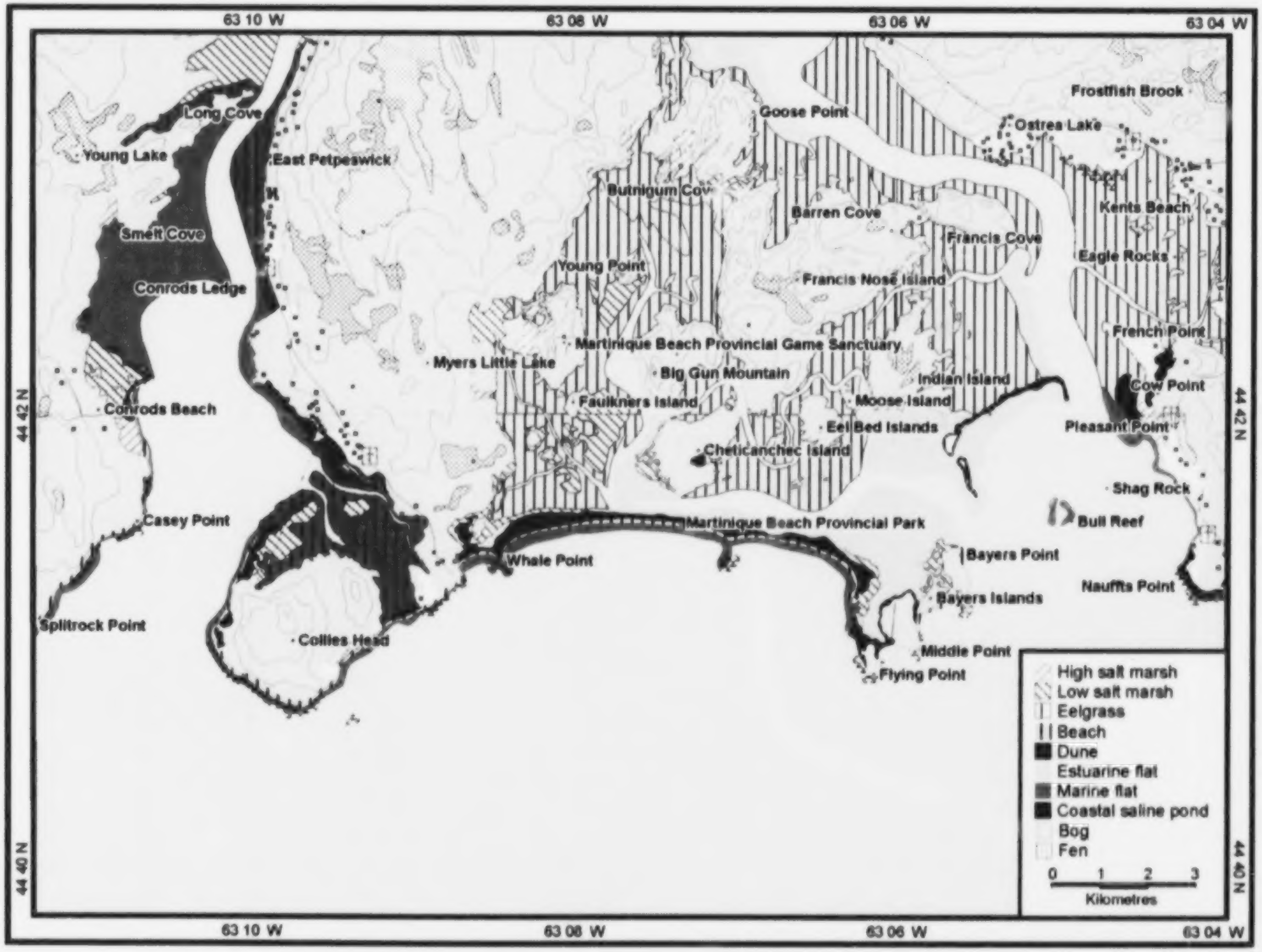

Figure 7-5a: Petpeswick Inlet and Musquodoboit Harbour area (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

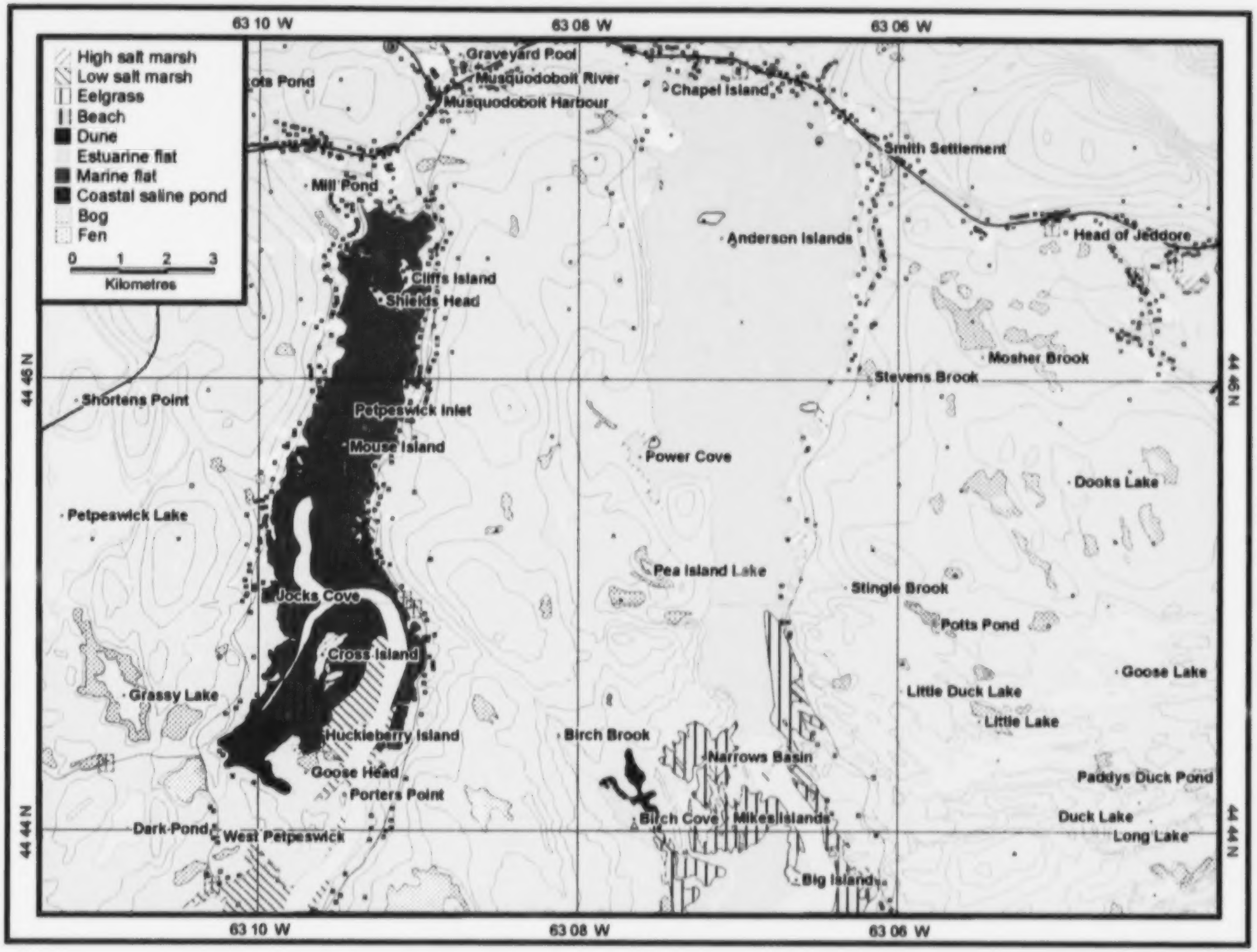

Figure 7-5b: Petpeswick Inlet and Musquodoboit Harbour area (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

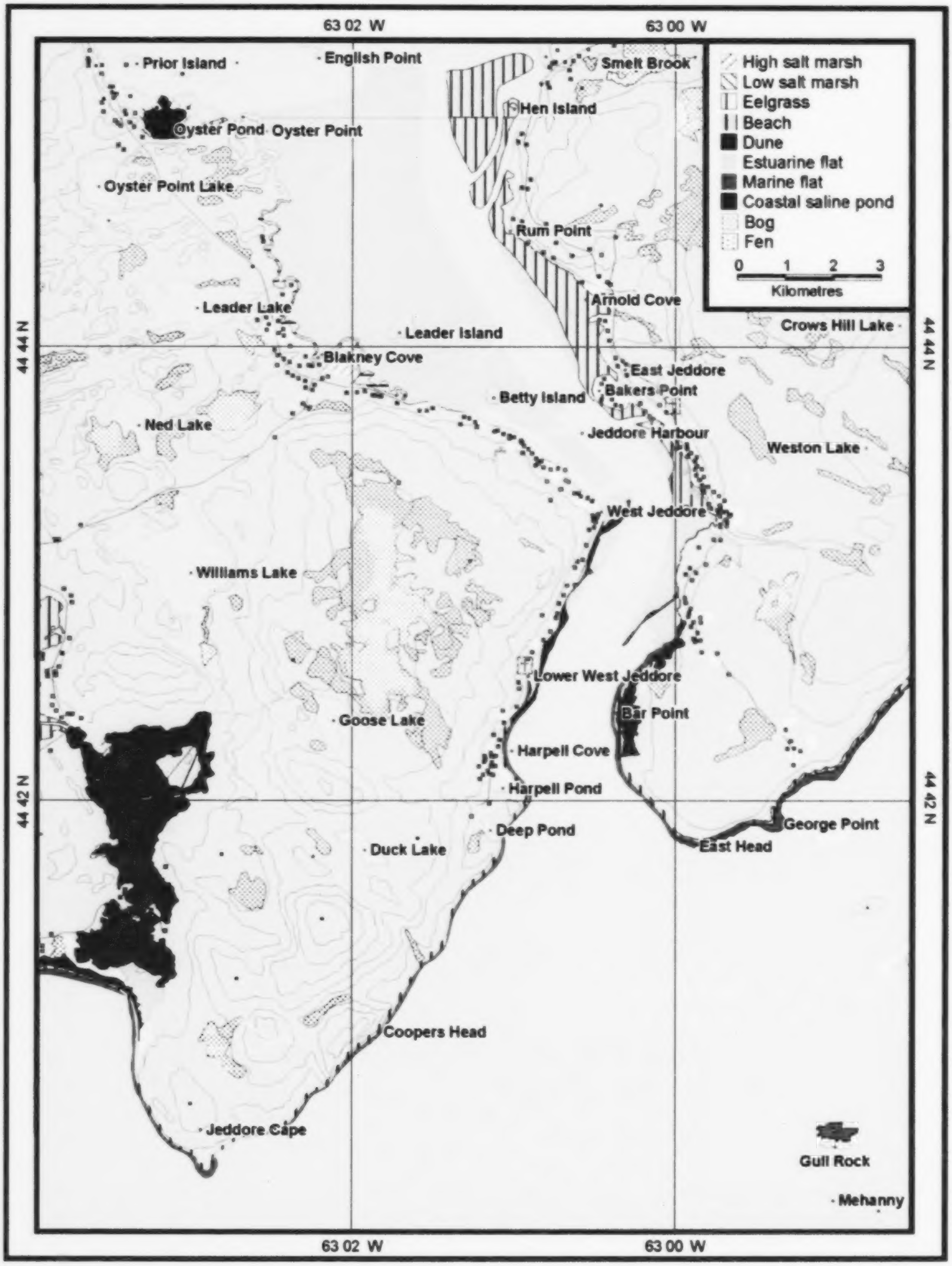

Figure 7-6: Jeddore Harbour area (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

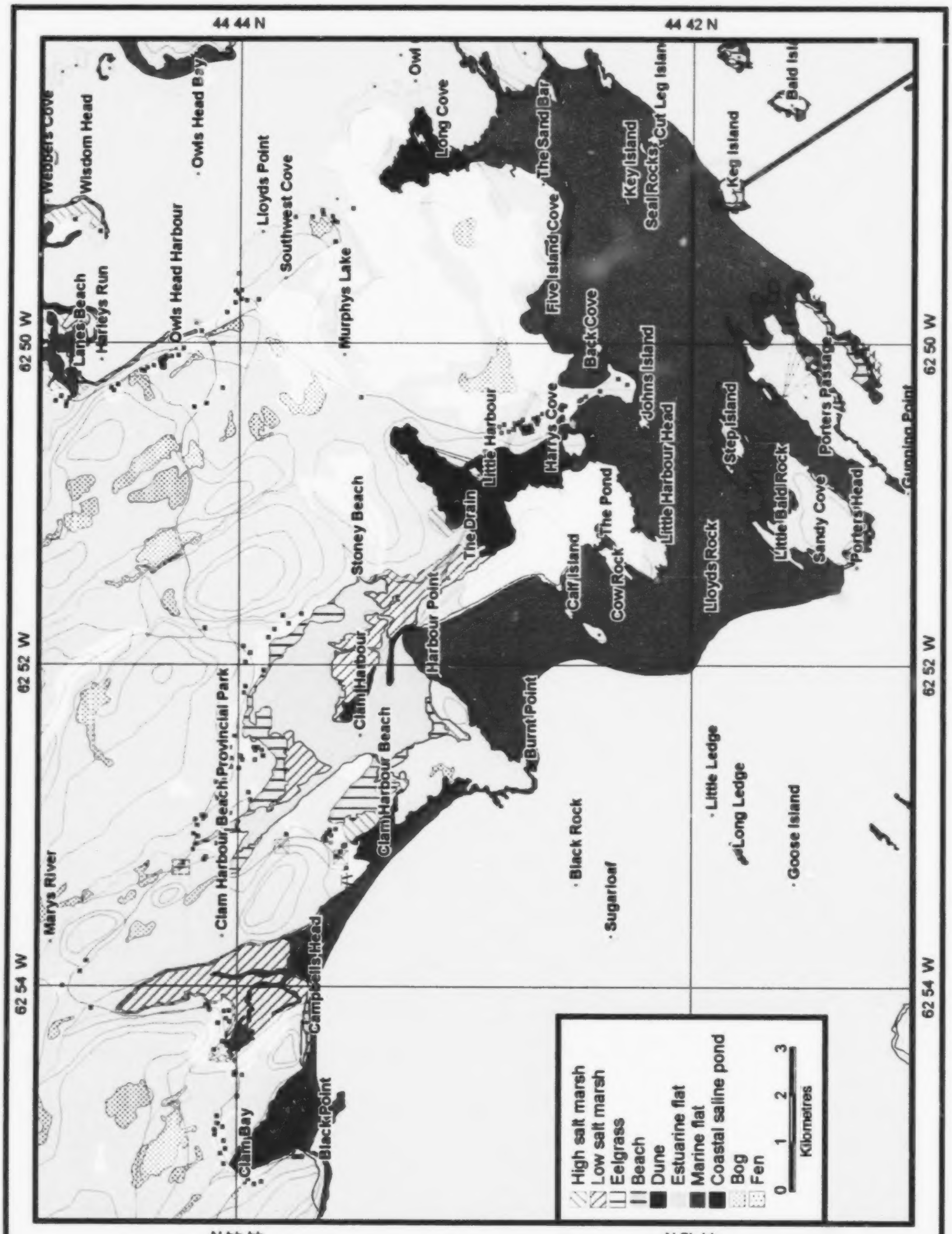

Figure 7-7: Clam Harbour area (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

Salt marshes

Salt marshes in Atlantic Canada are the northern extension of the vast salt marsh complex of the Gulf of Mexico and the east coast of the United States (Chapman 1974, Reimold 1977). In Atlantic Canada, they comprise a small part of the total wetland area (NWWG 1988). Historically, there were more than 32 000 ha of salt marsh land in Nova Scotia, over half of which have been dyked for agricultural use (Hilchey 1981). Today, there are approximately 13 000 ha of functioning salt marsh in the province (Kolstee 1999 as cited in Bowron et al. 1999). Salt marshes generally occupy a narrow zone between higher high water and mean sea level (Chapman 1960, Scott and Medioli 1980a) except in the extreme tidal ranges of the Bay of Fundy (Smith et al. 1984) where the vertical range of the marsh varies between 1-4 m (NWWG 1988).

Salt marshes are terrestrial extremes of the marine environment (NWWG 1988). Plants that occur there are land species that cannot compete with other terrestrial species (Hatcher et al. 1981) but can withstand saline conditions (Phleger 1971). In Atlantic Canada, salt marshes are characterized by salinities of 1- 400 ppt (Scott and Medioli 1980b) and vegetation dominated by *Spartina alterniflora* (smooth cordgrass) and *Spartina patens* (salt meadow hay) which occur rarely in other Canadian salt marshes.

Salt marshes are typically divided into high marsh and low marsh, each with a distinct plant community (Figure 7-8). Low marsh is the portion of the salt marsh below mean high water that is typically flooded daily by tides (Hanson and Calkins 1996). *Spartina alterniflora* is the dominant species in the low marsh. Other species that may be present are *Pucinellia maritima* (common salt marsh grass), *Salicornia europaea* (common glasswort), *Suaeda maritima* (seablite) and *Atriplex patula* (common oracle).

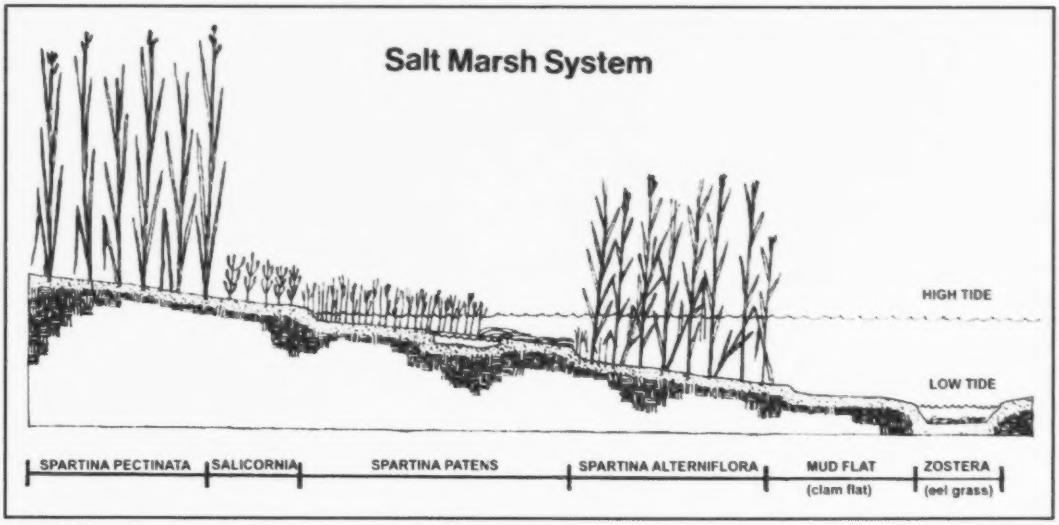

Figure 7-8: Vegetation zones in a typical salt marsh system (Smith et al. 1976)

The high marsh is the portion of the salt marsh above mean high water that is flooded only rarely by the highest tides (Hanson and Calkins 1996). The dominant vegetation is *S. patens*. Other plants characteristically found on the higher parts of the marsh are *Limonium carolinianum* (sea lavender), *S. europaea*, *Suaeda linearis* (annual seepweed), *A. patula*, *Plantago maritima* (sea plantain), *Puccinellia maritima*, *Triglochin maritima* (sea arrow grass), *Glaux maritima* (sea milkwort) and *Hordeum jubatum* (foxtail barley) (Glooschenko 1979). Nova Scotia is near the northern limit of *S. patens* and *S. alterniflora* distribution. On the Atlantic coast, *Carex palacea* (salt marsh sedge) is often the dominant high marsh species (Patriquin 1981).

Spartina alterniflora is the primary colonizer of a salt marsh and is generally found on the lower portion of the salt marsh where tidal inundations of the marsh commonly occur (Patriquin 1981). *Spartina alterniflora* can grow in fresh or brackish waters but is restricted to habitats with salinities between 20-30 ppt. It possesses several mechanisms for coping with high salt concentrations. It has also adapted to growing in waterlogged, poorly aerated soils.

Salt marshes are highly productive areas year round (Teal and Teal 1969) and are a major factor in the food chain of estuaries (Patriquin 1981). The year round photosynthetic activity in a marsh maintains the productivity above that of adjacent land area (Teal and Teal 1969). No agricultural crop, with the possible exception of rice or sugar cane, comes close to the production levels, in terms of food, as a salt marsh (Teal and Teal 1969).

Tidal marshes undergo a distinct seasonal cycle in most of Nova Scotia (Davis and Browne 1996). During the winter, ice and wave action strip the lower exposed portions of the marsh, leaving a stubble field. Spring growth results in a bright green lawn that grows well throughout the summer. Autumn frosts turn the marshes a rusty brown. The scraping during winter and the sloughing off of leaves in summer provides food for marine organisms and is essential to maintaining the important role of salt marshes in marine communities.

A range of animals inhabit salt marshes. Invertebrate marine species, including amphipods (*Gammarus* spp.) and isopods (*Idotea* spp.), various bivalve molluscs such as the blue mussel and the soft-shelled clam, and several gastropod species such as periwinkles and the eastern mud snail, live on the sediments (Davis and Browne 1996). Terrestrial arthropods such as spiders and insects are found on *Spartina* during the growing season. Killifish, stickleback, silversides and eels can be found in salt marshes as well as juveniles of local fish species such as the flounder.

Many bird species use salt marshes as important feeding, overwintering and breeding habitats (Davis and Browne 1996). Some species of duck, heron and shorebird depend on food organisms nourished by salt marsh production. The Sharp-tailed Sparrow uses the salt marsh for breeding.

Salt marshes typically develop on stable or emerging shorelines when sediment accumulates in estuaries, behind spits, offshore bars or islands, or in protected bays (Patriquin 1981, Davis and Browne 1996). The key features involved in salt marsh development are the role played by vegetation and the supply of silt to build up the surface (Patriquin 1981). *Spartina alterniflora* colonization accelerates the accumulation of sediment and helps to develop conditions suitable to further marsh formation (Davis and Browne 1996). In Nova Scotia where coastlines are submerging at a slow pace, salt marshes develop when the rate of sedimentation exceeds the rate of submergence. Once the sediments have accumulated to the mean high water level, no further development will occur unless there is some disturbing factor (Patriquin 1981).

Salt marshes along the Atlantic coast of Nova Scotia are limited in lateral extent and characterized by low marsh vegetation (Hatcher and Patriquin 1981). They seem to be just keeping pace with sea-level rise. The locations of some extensive (> 0.5 ha) salt marsh systems in Units 5 and 6 are given in Table 7-3. In Unit 4, some smaller salt marshes are present at several locations, including Isaacs Marsh and Dogwood Creek in Sambro Harbour, Indian Harbour, Back Bay and on Roost Island, Shannon Island and Boutlier's Point (HCESCRMP 1996). Table 7-4 gives the number and area of salt marshes at various locations within Units 5 and 6.

Table 7-3: Location of extensive salt marshes in Units 5 and 6 (NSDNR 2002)

Unit 5	Unit 6
Cow Bay	Adjacent to Kirby River
Cole Harbour	
West Marsh	
Lawrencetown Lake	
Chezzetcook Inlet	
Petpeswick Inlet	
Clam Harbour	

Table 7-4: Number and area of salt marshes at various locations in Units 5 and 6 (Lirette 1988)

Location	Number	Area (ha)
Cole Harbour	15	93
Lawrencetown	19	82
Three Fathom Harbour	2	8
Chezzetcook	10	219
Petpeswick	9	122
Musquodoboit	15	135
Jeddore	7	13
Clam Bay	15	112
Ship Harbour	2	12
Tangier	7	13
Mushaboom	1	0.4
Sober Island	8	23
Bay of Islands	8	32
Ecum Secum	1	17
St. Mary's River	3	9

Salt marshes perform various functions, including (MacKinnon and Scott 1984):

- providing important habitat for various fish species;
- providing important habitat for migratory birds and other animals;
- performing waste treatment;
- buffering against storms;
- buffering against oil spills;
- protecting beaches; and,
- aiding in normal functioning of the global cycles of nitrogen and sulfur.

Threats to salt marshes

Salt marshes are threatened by several factors, including dyking, construction of tidal dams, oil spillage and coastal development (MacKinnon and Scott 1984). Dyking is responsible for the destruction of more than half the natural salt marshes in Nova Scotia. Salt marshes were originally dyked by the Acadians in the 1600s to drain the marshlands for agricultural use. In the late 19th and early 20th centuries, dyked salt marshes were very profitable for their hay crops. In the early 1970s, approximately 65% of salt marshes remained dyked (Reed and Smith 1972).

The construction of dams for tidal power development threatens salt marshes in the area (MacKinnon and Scott 1984). Dams constructed at the mouth of bays may increase the average water level, reducing the upper limit of tidal range and isolating the marsh area from tidal activity. For example, a tidal dam at Annapolis converted a former salt marsh into pastureland.

Salt marshes are threatened by oil spillage. To a certain extent salt marshes can act as buffers against oil spills (Patriquin 1981). In these cases, the lower salt marsh can protect the upper salt marsh and other land from oil damage. However, whereas pulse oil pollution causes little long-term damage to perennial salt marsh grasses, annuals may be severely affected. In addition, large long-term spills can destroy the salt marsh and its inhabitants.

Increasing coastal development threatens salt marsh communities in various ways. Construction of buildings, roadways, railways and ports can alter and destroy salt marsh habitat (MacKinnon and Scott 1984). Dredging leads to increased turbidity, sediment build-up, reduced oxygen, disruption and removal of organisms, creation of stagnant deepwater areas and disruption of circulation (McHugh 1976), all of which effect nutrient production and distribution, and disrupt important habitats of various organisms (McKinnon and Scott 1984).

Natural pressures such as snow, ice and drought may threaten salt marshes (MacKinnon and Scott 1984). Flooding, storm surges and changes in water current and sediment patterns may also cause damage (Bowron pers. comm. 2004).

Eelgrass

Zostera marina or eelgrass is one of 47 species of seagrasses found in nearshore coastal environments and estuaries (Phillips 1984). Eelgrass and other seagrasses have two morphological adaptations that are unique for submerged plants and enable them to live in an aquatic environment exposed to wave and tidal action, and shifting sediments (Thayer et al. 1984). These characteristics are straight, grass-like leaves that extend upright in the water column and an extensive rhizome and root system (Phillips 1984, Thayer et al. 1984). The leaves are adapted to facilitate light penetration, gas diffusion, and buoyancy (Thayer et al. 1984). Leaves and stems are generally thin, have a comprehensive system of air spaces and reduced structural tissue. The thin walls enhance diffusion of gases and nutrients. Photosynthesis occurs primarily in the epidermal layer of the leaves that possess high concentrations of chloroplasts. This feature is crucial to the ability of seagrasses to grow and survive in turbid coastal waters, characteristic of temperate areas (Thayer et al. 1984).

The seagrass root and rhizome system anchors the plant and absorbs nutrients from interstitial water in the sediment (Thayer et al. 1984). The extensive air space system permits submerged seagrasses to anchor oxygen-requiring roots in anaerobic sediments and unconsolidated soft substrate. These features of the root-rhizome system are a primary reason why eelgrass has been able to colonize in almost liquid mud.

Eelgrass meadows are ranked among the most productive of marine plant ecosystems (McRoy and McMillan 1977). Like other seagrasses, eelgrass performs several functions in its environment. It provides food in two ways: direct grazing on the living plant, and utilization of detritus from decaying eelgrass material such as leaves (Zieman 1982). The presence of eelgrass on and penetrating into the substrate provides a structured habitat from an unstructured one, thus creating a diversity of habitats (Phillips 1978). Densities of sessile and mobile fauna typically exceed those in unvegetated habitats (Thayer et al. 1984). Eelgrass communities provide a nursery ground for food and protection for juveniles of various finfish and shellfish species (Zieman 1982). Eelgrass stabilizes sediments via two mechanisms: rhizomes and roots form an interlocking matrix that adheres sediment and slows erosion; and leaves slow current flow, reducing water speed and promoting sedimentation of particles while inhibiting resuspension of organic and inorganic material (Zieman 1982). Seagrass acts as a nutrient pump for the sediment by absorbing nutrients from the sediments and releasing them from their leaves into the water (Zieman 1982).

Various plants and animals are associated with eelgrass communities. A diverse range of epiphytic organisms, including bacteria, microalgae, macroalgae and fauna grow on the leaves of the plant (Harlin 1980). In the Kouchibouguac area of New Brunswick, the red alga (*Polysiphonia subtilissima*) and blue-green algae are common epiphytes on eelgrass leaves (Patriquin and Butler 1976). There are ninety-one (91) species of microalgae and one hundred and twenty-four (124) epiphytic faunal species that have been reported on eelgrass leaves (Harlin 1980).

Benthic and epibenthic fauna found on eelgrass beds along the east coast of North America include cnidaria, gastropods, bivalves, polychaetes, amphipod crustaceans, isopod crustaceans, tanaid crustaceans, cumacean crustaceans, shrimp, crabs and echinoderms (Thayer et al. 1984). At different latitudes, however, the species composition of benthic fauna in eelgrass meadows may vary greatly (Thayer et al. 1984).

The nekton component of eelgrass beds is dense and diverse compared to the fish community found in unvegetated habitats (Thayer et al. 1984). Eelgrass beds are important nursery and feeding grounds for a wide variety of nektonic species, many of which are commercially or recreationally valuable, or important as food for other fish and birds. Eelgrass beds serve as important nursery habitat by providing protection from predators, substrate for attachment of sessile stages and an abundant food supply (Thayer et al. 1979).

Fish species found in eelgrass beds in Kouchibouguac estuary, New Brunswick, include Atlantic tomcod (*Microgadus tomcod*), winter flounder (*Pleuronectes americanus*), sand shrimp (*Crangon septemspinosa*), threespine stickleback (*Gasterosteus aculeatus*) and cunner (*Tautogolabrus adspersus*) (Joseph et al. 2004). Eelgrass beds appear to be particularly important as nursery habitat for juvenile white hake (*Urophycis tenuis*) and small cunners. Other species typically found in eelgrass beds include Northern pipefish (*Syngnathus fuscus*), Atlantic silversides (*Menidia menidia*) and American eels (*Anguilla rostrata*) (Davis and Browne 1996). In Newfoundland, juvenile Atlantic cod densities are highest in eelgrass beds (Ings et al. 2004).

The rate of development of an eelgrass meadow depends on several factors, including: how rapidly shoots are added and lost to the population, the period of time during the year they are added or lost, and the initial density and spacing of the shoots (Thayer et al. 1984). The first two factors are controlled directly by environmental conditions, particularly light, temperature and nutrients, and indirectly by hydrodynamic conditions. Less is understood about the factors affecting shoot spacing, but meadows in areas with high currents and waves are more densely packed (Thayer et al. 1984) and have more root standing crop (Kenworthy et al. 1982).

Along the east coast of North America, eelgrass ranges from northern Labrador south to North Carolina where it dominates the seagrass communities (den Hartog, 1970; Thayer et al. 1984). It has successfully colonized areas with sediments ranging from soft mud to coarse sand substrates, average salinities of 10-30 ppt and water temperatures from below 0 C to greater than 30 C.

In Nova Scotia, eelgrass is commonly found in shallow inlets and embayments (Keddy and Patriquin 1978) and often in areas near high-velocity channels (Smith et al. 1976). It frequently occurs in the lower intertidal and subtidal zones adjacent to salt marshes (Patriquin 1981). Along the east coast of Nova Scotia, an annual form of eelgrass inhabits intertidal and shallow subtidal mudflats and a perennial eelgrass forms extensive beds in the subtidal region (Robertson and Mann 1984). In Petpeswick Inlet (Unit 5) (Figures 7-5a and 7-5b), the annual form has also been found to inhabit ponds on raised *S. alterniflora* flats; depressions which drain with each low tide that are scattered over raised *S. alterniflora* flats; and creeks in *S. alterniflora* marshes (Keddy 1987). In Units 5 and 6, eelgrass is often found in coastal saline ponds and on estuarine flats.

Locations of some extensive eelgrass beds in Units 5 and 6 are given in Table 7-5. Although NSDNR (2002) reports no eelgrass in Unit 4, others have reported its presence in that area. HCESCRMP (1996) indicates the presence of eelgrass in Redmonds Cove, Peggy's Cove, Shad Bay and Prospect Bay. Eelgrass beds in St. Margarets Bay were found in sheltered inlets at the head of the Bay, and on the sheltered side of islands, at depths of 2-5 m and typically on muddy substrates (Mann 1972).

Table 7-5: Location of some extensive eelgrass beds in Units 5 and 6 (NSDNR 2002)

Unit 5	Unit 6
Cow Bay	Kirby River
Cole Harbour	
West Marsh	
Lawrencetown Lake	
Three Fathom Harbour	
Chezzetcook Inlet	
Petpeswick Inlet	
Musquodoboit Harbour	
Jeddore Harbour	
Little Harbour	

Eelgrass wasting disease

In the early 1930s eelgrass underwent a widespread decline in the Atlantic Ocean, with an estimated 90% destroyed throughout its range in the Atlantic (Tutin 1942). Various agents, including a slime mold, bacteria, fungi, pollution, commercial harvesting of fishery organisms and competing species, were theorized to be the cause of the decline (Thayer et al. 1984). Finally, the fungus *Labyrinthula* sp. was identified as the pathogen (den Hartog 1970).

After the decline, geomorphological and biological changes were reported in some regions. In Denmark, substrates became coarser, permanent sand bars occurred and deposits of fine mud adjacent to areas of destroyed eelgrass beds changed from anoxic to oxidized sediments (Rasmussen 1973 & 1977). Sandy beaches once protected by eelgrass became rocky shores. Similar occurrences may have happened in the Northwest Atlantic (Stauffer 1937).

Along the North American Atlantic coast, changes in faunal communities were reported. Fisheries were affected by the loss of eelgrass (Thayer et al. 1975, Zieman 1982). Declines in abundance of cod, shellfish, scallops, crabs (Milne and Milne 1951), lobsters and eels (Dexter 1947) were noted. In most cases, however, declines in abundance could not be recognized quantitatively because most of the literature on fauna associated with eelgrass before the decline was qualitative. In Kouchibouquac no major differences in fisheries were observed between the presence and absence of eelgrass in the region (Patriquin and Butler 1976).

Species that were notably impacted by the decline of eelgrass were the Atlantic Brant (*Branta bernicla hrota*), the bay scallop (*Argopecten irradians*) and to a lesser extent, the Canada Goose (*Branta canadensis*). The Atlantic Brant fed almost exclusively on eelgrass and almost vanished after its decline (Cottam 1934, Cottam et al. 1944, Cottam and Munro 1954, den Hartog 1977). Its autumn migration pattern changed and no longer included a route along the coast of New Brunswick and Nova Scotia (Hanson 2004a). It wasn't until the 1950s that the Brant population recovered, at which time its diet shifted to sea lettuce (*Ulva lactuca*) and widgeon grass.

The bay scallop feeds on eelgrass-derived detritus (Kirby-Smith 1972, Kirby-Smith and Barber 1974) and can obtain up to 30% of its body carbon from detritus (Thayer et al. 1978). It depends on seagrass blades for attachment of its postlarvae (Gutsell 1930, Thayer and Stuart 1974). Following the decline of eelgrass, the commercial harvest of the bay scallop in Chesapeake Bay and North Carolina declined drastically. In North Carolina, recovery took almost 30 years

(Thayer and Stuart 1974) and in Chesapeake Bay, levels have never returned to commercially harvestable quantities (Orth and Moore 1982 as cited in Thayer et al. 1984).

Trends in the Maritime provinces

Eelgrass trends in the Maritime provinces suggest a widespread decline in abundance and distribution (Hanson 2004b). Locke and Hanson (2004) reported an average reduction in eelgrass biomass of 40% between 2001 and 2002 in 13 southern Gulf of St. Lawrence estuaries, including Tatamagouche, Merigomish, Caribou and Pomquet in Nova Scotia. An 88% reduction was documented in Rustico, Prince Edward Island.

Sharp and Semple (2004) estimated an eelgrass decline of 30% and 44% between 1978 and 2000 for two areas in Lobster Bay, Yarmouth County. Chapman and Smith (2004) estimated an average decline of 80% of eelgrass beds over 10 years (1992-2002) in four inlets (Cole Harbour, Chezzetcook, Petpeswick and Musquodoboit Harbour) along the Atlantic coast of Nova Scotia (Unit 5). Cole Harbour had the smallest reduction (49%), whereas Petpeswick had the greatest decline (96%).

Garbary et al. (2004) documented a 95% decline in eelgrass in Antigonish Harbour between 2000 and 2001. They also reported eelgrass declines in 31 of 40 sites along the Atlantic shoreline from Yarmouth to Merigomish. Garbary et al. (2004) conclude that a major decline in eelgrass has occurred over the last 3-6 years in Nova Scotia, with significant negative impacts, including a 50% decline in migrating Canada Geese at one site, adverse effects on detritus-based food chains in coastal waters, and a decrease in estuarine biodiversity.

Threats to eelgrass

The shallow, subtidal existence of eelgrass makes it susceptible to disruptions of both the water column and sediments (Thayer et al. 1984). Thus eelgrass is threatened by a variety of factors. Reduction of light due to degradation of water quality by nutrient loading or sediment loading is one of the greatest threats to eelgrass (Wippelhauser 1996). Nutrient loading can result from effluents from wastewater treatment facilities and aquaculture sites, and runoff from agriculture, animal wastes and fertilized lawns (Short 1992 as cited in Wippelhauser 1996). Excessive nutrients can reduce the amount of light reaching eelgrass, eventually destroying it, by promoting the growth of epiphytes on eelgrass leaves, phytoplankton in the water column and entangling macroalgae (Orth and Moore 1983, Kemp et al. 1983, Thayer et al. 1984, Twilley et al. 1985, Dennison 1987). Sediment loading from various sources can also reduce the amount of light reaching eelgrass by reducing the amount of light that penetrates the water (Dennison 1987).

Dredging and filling are major threats to eelgrass (Thayer et al. 1984, Wippelhauser 1996). Dredging and filling may alter physical environments by modifying current velocity, wave activity, substrate composition and depth to the bottom, thus preventing eelgrass from reproducing (Wippelhauser 1996). In addition to physically displacing eelgrass, dredging causes sediments to accumulate thus reducing light to eelgrass.

Certain fishing and boating activities (e.g., use of boat propellers) may uproot eelgrass plants and resuspend sediments (Thayer et al. 1984, Wippelhauser 1996). Scallop dredging may reduce biomass, surface area and shoot density of eelgrass growing on soft and hard substrates (Fonseca et al. 1984).

Fluctuations in temperature and salinity above or below optimum ranges may inhibit metabolism and decrease an eelgrass plant's productivity (Thayer et al. 1984). For example, the creation of dykes, groins and jetties may alter circulation patterns, elevating the temperature of a local eelgrass bed. Similarly freshwater discharge can dilute estuarine waters, reducing the salinity and thus causing less than optimal conditions for existing eelgrass meadows.

Eelgrass is threatened by several other factors. In some areas, eelgrass is harvested to make a natural, non-toxic insulation (Wippelhauser 1996). Thus, overharvesting may be a potential threat to eelgrass. Petroleum, herbicides and pesticides may have adverse effects on eelgrass (Thayer et al. 1984).

Natural causes of episodic reduction of Atlantic eelgrass such as the wasting disease experienced in the 1930s remain a threat to eelgrass (Wippelhauser 1996). The wasting disease has recurred since the 1930s (Short et al. 1986, Short et al. 1987, Short et al. 1993). For example, roughly 80% of the eelgrass in Great Bay, New Hampshire and the majority of eelgrass in the Piscataqua River were destroyed due to the wasting disease between 1981 and 1989 (Short et al. 1993). Unfortunately, no treatments are available to prevent the wasting disease or relieve its adverse effects (Wippelhauser 1996).

Recently, green crabs (*Carcinus maenus*), an invasive species, have been suggested as the cause of decline of eelgrass in some regions due to their foraging behaviour (Garbary et al. 2004). Green crabs have become widely distributed and are abundant along the Atlantic coast of Nova Scotia. They remove eelgrass shoots by digging burrows in search of benthic bivalves (Garbary et al. 2004). They also shred and cut eelgrass shoots that get in the way of their digging activities. Green crabs may also cause increased epiphyte loading that may increase the buoyancy of eelgrass shoots, potentially facilitating the removal of rhizomes from the substrate.

Worm and clam harvesting may threaten eelgrass beds in some areas (Garbary and Munro 2004). Although harvesting of these species typically occur on mud flats, adjacent eelgrass meadows may be trampled by harvesters. Mussel and oyster harvesting and aquaculture in estuaries are a potential threat to eelgrass. Although impacts on eelgrass from aquaculture are unknown, nutrient loading from bivalve waste and shading from suspended mussel socks may have adverse effects on eelgrass.

Bogs and fens

Bogs and fens are peatlands that form through the growth and accumulation of vegetation remains on poorly draining soils (NWWG 1988). Whereas bogs have water tables at or near the surface, fens have water tables at or just above the surface (i.e., a high water table). A major difference between bogs and fens is their nutrient status. Bogs are nutrient-poor, receiving their nutrients only from atmospheric sources such as precipitation and atmospheric dust. Although fens also receive nutrients from atmospheric sources, they are nutrient-rich because they obtain supplementary nutrients from seepage waters from surrounding or adjacent upland soils. In addition, *Sphagnum* mosses, dwarf shrubs and lichens dominate the vegetation of bogs whereas fens consist primarily of sedges and grasses with some *Sphagnum* mosses. The growth and accumulation of *Sphagnum* mosses is the major contributor to peatland formation in Atlantic Canada and in particular to bogs. However, these mosses play only a small role in the formation of fens that are dominated by sedges and grasses.

Although the majority of bogs and fens are inland freshwater wetlands, some of them are found in coastal areas. In Units 4, 5 and 6 only two fens are considered coastal; one occurs adjacent to Kirby River in Unit 6 and the other in Lawrencetown Lake in Unit 5 (NSDNR 2002). Coastal bogs are more numerous than fens in Units 4, 5 and 6 (Table 7-6).

Table 7-6: Locations of bogs in Units 4, 5 and 6 (NSDNR 2002)

Unit 4	Unit 5	Unit 6
Sambro Basin	Lawrencetown Lake	Taylors Head
	Three Fathom Harbour	Sober Island
	West Marsh	East of Williams Reef
		Wolfes Island
		North Mud Hole, Gerard Island

Bogs and fens can generally be distinguished from each other on the basis of nutritional and vegetative characteristics (NWWG 1988). However, the range of these factors may not remain constant throughout the range of bogs and fens. For example, the vegetative composition and chemical parameters of bogs in oceanic areas frequently vary from those in continental areas due to increased precipitation and added nutrient input from sea spray.

The rate of decomposition of plant matter in a bog is slower than the rate of production (Butler et al. 1996). As a result, the partially decomposed plant material accumulates and forms peat, on which *Sphagnum* mosses grow. When the mosses die, they amass as peat. As peat collects, the bog expands upward and sideways. Peat accumulates at a rate of 0.5-1.5 mm/year. In bogs peat can be up to 9 m thick, although on average it is approximately 3 m thick. Rates of plant production are typically higher in fens than in bogs but peat accumulation is less than that in bogs because rates of plant decomposition are high (NWWG 1988). Fen depths in Atlantic Canada vary from 0.5-2 m.

Bogs contribute considerably to regional biodiversity (Mazerolle et al. 2001) by providing habitat for endemic and rare species of plants (Poulin et al. 1999), insects (Rosenberg and Danks 1987, Larson and House 1990), birds (Calmé and Desrochers 1999) and small mammals (Nordquist 1992). In eastern North America, three small mammals prefer peatland habitat: the northern bog lemming (*Synaptomys borealis*), southern bog lemming (*S. cooperi*) and the Arctic shrew (*Sorex arcticus*) (Banfield 1977 as cited in Mazerolle et al. 2001, Nordquist 1992).

Threats to bogs

Bogs are threatened by rising sea levels that may cause gradual loss of peat habitat, the draining of peatlands for development and the mining of peat (Butler et al. 1996). Industrial, agricultural and urban development degrade peatland habitat and threaten bogs (Rubec 1996). All-terrain vehicle (ATV) use can damage bog habitat (Bridgland 2003).

Peat mining is an expanding industry in Canada (Keys 1992). In southeastern Canada, large bogs with deep layers of organic matter are particularly valuable because they offer a considerable abundance of horticultural peat (Mazerolle et al. 2001). Peat mining drastically alters the structure of bogs by introducing networks of drainage ditches and eliminating the living vegetation layer (Mazerolle and Cormier 2003). As a result, dry conditions over the bog are generated, facilitating the removal of peat with tractor-pulled vacuums (Wheeler and Shaw 1995). Peat is mined for use in horticulture and as fuel. Peat mining is known to have adverse effects on amphibians (Mazerolle 1999) and birds (Calmé and Desrochers 1999, Delage et al. 2000).

All-terrain vehicles can severely impact wetland habitats and impair ecosystem functions. All-terrain vehicles can crush and kill natural vegetation. In a study undertaken in the Cape Breton Highlands to determine the nature and scope of environmental damage caused by ATVs to bogs, impact tests showed that after only 10 ATV passes, 50% of the vegetative cover of the impacted trails had been destroyed. After 40 passes by an ATV virtually 100% of the vegetative cover had been destroyed (Ross 1991). All-terrain vehicles can create bare soil trails that erode during rainfall. The eroded soil can end up in wetlands, reducing the quality of habitat for invertebrates and fish.

Coastal saline ponds

Coastal saline ponds, also known as coastal salt ponds or saline lagoons, are bodies of saline water that are partially separated from the sea (UKBG No date). They generally lie adjacent to the ocean and are separated from it by a barrier of sand to cobble sized particles created by the tide through which sea water either percolates or infiltrates through a narrow channel (UKBG No date, Hanson and Calkins 1996). Coastal saline ponds may be occasionally open to the sea or have a regular drainage opening to the ocean (Hanson and Calkins 1996). The connection to the sea may be periodically opened and closed by the shifting of barrier sands (WHRC 1998). Locations of some coastal saline ponds in Units 4, 5 and 6 are given in Table 7-7. Numbers and total areas of coastal saline ponds in various locations in Units 5 and 6 are shown in Table 7-8.

Table 7-7: Location of coastal saline ponds in Units 4, 5 and 6 (NSDNR 2002)

Unit 4	Unit 5	Unit 6
Terence Bay	Cow Bay	Sober Island Pond
The Head	Three Fathom Harbour	Powers Pond, Taylor Head Provincial Park
	Grand Desert Beach	Shiers Pond
	Miseners Lake	
	Oyster Pond	
	Navy Pool, Jeddore Harbour	
	Lawrencetown Lake	

Table 7-8: Number and area of coastal saline ponds at various locations in Units 5 and 6 (Lirette 1988)

Location	Number	Area (ha)
Three Fathom Harbour	6	82
Chezzetcook	3	50
Musquodoboit	2	98
Jeddore	3	86
Clam Bay	4	72
Mushaboom	2	22
Sober Island	1	73
Bay of Island	1	15
Necum Teuch	1	4
St. Mary's River	5	16

Although their name is derived from their proximity to and relationship with the sea, coastal saline ponds have a continuous freshwater source via groundwater flow from watersheds, rainfall and streams (Culbert and Raleigh 2001). Therefore their physical properties may vary considerably. Although coastal saline ponds are generally brackish to fully saline (Hanson and Calkins 1996), salinity levels may vary from fresh to saline water, depending on the influx of freshwater (UKBG No date, Culbert and Raleigh 2001). A coastal saline pond may be completely saline near its connection with the ocean but largely freshwater adjacent to groundwater seepage areas or stream inflow at the other end (Culbert and Raleigh 2001, UKBG No date). Some areas within coastal saline ponds exhibit large temporal fluctuations in salinity whereas others maintain fairly constant levels (Culbert and Raleigh 2001).

The salinity gradient in the pond segregates much of the plant and animal life because different organisms tolerate different salinities (WHRC 1998). However, some organisms will not survive the sudden changes in salinity that may occur with the opening and closing of the seawater source. When the seawater inlet is closed for a long period of time, large-scale die offs will occur among plant and animal communities, and massive decay will give off bad odours and make the pond unattractive. When the pond is reopened via a breach in the barrier beach and seawater can once again infiltrate the pond, the organisms adapted to the fresher water conditions will die off because they cannot tolerate the increasing salinity levels.

Coastal saline ponds may have short geological lifespans, lasting for less than 1000 years (Barnes 1980). Due to coastal processes, the barriers may gradually move inland, encroaching on the pond behind them. Over time this may cause the infilling of the pond. Development on the landward side of the pond may accelerate this process by preventing the landward extension of the pond. Severe storms may also destroy the pond by breaching the natural barrier and creating a bay (UKBG No date).

Coastal saline ponds support a myriad of wildlife and vegetation. In the coastal saline ponds of Long Point Wildlife Refuge in Martha's Vineyard, more than 100 species of vegetation, many of which are flowering plants along the shore, are found in and around the ponds (Culbert and Raleigh 2001). Distinct communities of submerged aquatic vegetation are found based on salinities, light levels and other factors. For example in brackish ponds, eelgrass is commonly one of the only plants present. Thirteen aquatic vegetation species were found growing on the bottoms of the ponds in Long Point Wildlife Refuge (Culbert and Raleigh 2001). The aquatic vegetation shelters many invertebrate and fish species from predatory invertebrates, fish, birds and mammals, and provides habitat for many invertebrate species to graze on algae and detritus. In Units 5 and 6, eelgrass is found in several saline ponds (e.g., see Figures 7-2, 7-5b and 7-7).

Coastal saline ponds support a variety of fish species. Twenty-three species of fish were caught in various locations within coastal saline ponds in Long Point Wildlife Refuge (Culbert and Raleigh 2001) and many of these species may use coastal saline ponds in Nova Scotia. Common residents include mummichogs (*Fundulus heteroclitus*), Atlantic silversides (*Menidia menidia*) and four-spine sticklebacks (*Apeltes quadracus*). Migratory species include the American eel (*Anguilla rostata*), Atlantic menhaden (*Brevoortia tyrannus*), striped cusk-eel (*Ophidion marginatum*), and summer (*Paralichthys dentatus*) and winter flounder (*Pleuronectes americanus*). The presence of each individual fish species depends greatly on the timing of the ponds' openings or closings and the relationship between these events and the species' life cycle. Fall pond openings are essential to fish species that use the pond as a nursery, such as menhaden and flounders, to allow the departure of juveniles to the ocean. Certain catadramous species, such as alewives, rely on spring openings to allow them access to their spawning grounds.

In a fresh to brackish coastal pond in Falmouth, Massachusetts, fish such as the American eel and several species of herring, use the pond for spawning (Emery 1997). Many freshwater and brackish water species, including yellow perch (*Perca flavescens*) and white perch (*Roccus americanus*) are also present. Common benthic species in the pond include amphipods, polychaete worms, hydroids, turbellarian worms and gastropods. Species present in coastal saline ponds may vary in different areas, depending on salinity levels and the extent of freshwater input.

While some species may rely on habitat within coastal saline ponds for their survival, there are also pond specialists. UKBG (No date) identifies 26 saline lagoon or pond specialists in Britain: seven plants, six mollusca, three cnidarians, two bryozoans, two polychaetes, one insect and five crustaceans. For example, Ivell's sea anemone, *Edwardsia ivelli*, which was only known to inhabit one coastal pond area, is now likely extinct.

Coastal saline ponds are important foraging and roosting sites for birds, particularly waders, wildfowl and seabirds (Culbert and Raleigh 2001). In Martha's Vineyard, Ringed Plovers (*Charadrius hiaticula*) and a myriad of migrating waders feed in the invertebrate-rich margins and shallows of the ponds. Deeper ponds in Martha's Vineyard support diving ducks in winter and during migration. Gulls also use the ponds as roosting sites. Coastal saline ponds may be visited by sea ducks, grebes and divers during storms and other bad weather.

Threats to coastal saline ponds

Due to limited tidal flushing, coastal salt ponds are very susceptible to degradation by pollution from a variety of sources, including road runoff and septic systems (WHRC 1998). The water quality in a coastal saline pond is threatened by bioaccumulation of chemicals such as chromium, lead, copper, cadmium, zinc, mercury, hydrocarbon, glycol and road salt from direct roadway runoff. Organic matter from roads may also enter the pond through direct runoff. Contaminants like zinc, mercury and copper can bioaccumulate in living tissue and cause problems for organisms inhabiting the pond as well as those that depend on the pond for their food source, including waterfowl and humans.

Construction (e.g., jetties) or other development in watersheds of coastal saline ponds can threaten these wetlands (Culbert and Raleigh 2001, WHRC 1998). Development, such as an increase in the number of houses, can increase nitrogen-loading due to an increase of septic systems in the area. Nutrient-loading from development in watersheds can lead to eutrophication and degradation of the pond (Culbert and Raleigh 2001). Dredging and filling may physically destroy coastal saline pond communities or increase the tidal flow, thus affecting plants and shellfish (WHRC 1998).

The introduction of an exotic or non-native species can disrupt the balance of a coastal saline pond (Culbert and Raleigh 2001). Exotic species from other continents have been introduced to local coastal waters, often transported on the outer hull of a ship or in the ballast waters taken on in faraway ports and then released in local harbours. In local areas, these exotic invertebrates or fish have few or no natural predators, allowing them to reproduce and multiply unchecked. New species can compete against local species for food, causing a decline in food resources for native species. Exotic species can also out-compete sessile animals and plants for their habitat and spread disease.

Mute Swans (*Cygnus olor*) are large, non-migratory birds, introduced to the eastern U.S. from Europe and Asia (Culbert and Raleigh 2001). They provide a good example of the potential negative impacts of exotic species on coastal saline ponds. Once they establish their territory in a coastal saline pond, they exclude other native ducks through aggression and by grazing the shallow areas of underwater vegetation. The destructive foraging habits of these birds can cause significant changes to wetland habitats; they rip the whole plant out of the mud instead of grazing on the blades and shoots of submerged aquatic plants. This type of foraging prevents regeneration of plants that provide habitat and oxygen for fish, a mechanism that is particularly important for small ponds that may be stressed from nutrient loading in rapidly developing coastal watersheds.

Estuarine and marine flats

Estuarine and marine flats are often referred to collectively as mud flats. There are, however, differences between them. Marine flats are mud and sandy mud areas exposed between the extreme high tide and extreme low tide marks (Davis and Browne 1996), and associated with a high-energy shoreline (Hanson and Calkins 1996). They are exposed to the waves and currents of the open ocean (Hanson and Calkins 1996). Consequently, the ebb and flow of oceanic tides are primarily responsible for determining water regimes in these areas. In contrast, estuarine flats are tidal habitats that are partially enclosed by land but have periodic, partially obstructed or open access to the ocean (Hanson and Calkins 1996). The ocean water of an estuarine flat is intermittently diluted by freshwater runoff from the land. The locations of extensive estuarine and marine flats in Units 4, 5 and 6 are given in Tables 7-9 and 7-10, respectively. Estuarine flats are the most extensive type of coastal wetland in Units 4, 5 and 6. The number and area of estuarine flats in these units are given in Table 7-11.

Table 7-9: Location of extensive estuarine flats in Units 4, 5 and 6 (NSDNR 2002)

Unit 4	Unit 5	Unit 6
Sellars Cove	Cole Harbour	Kirby River
Frostfish Cove	Chezzetcook Inlet	
Little Island Point	Musquodoboit Harbour	
Around Sheas Island	Jeddore Harbour	
Indian Harbour	Clam Harbour	
Sambro Basin	Lawrencetown Lake	
	West Marsh	

Table 7-10: Location of extensive marine flats in Units 4, 5 and 6 (NSDNR 2002)

Unit 4	Unit 5	Unit 6
Sand Bay	Along South East Passage, Halifax Harbour	False Passage (between Cable Island and Wolfes Island)
Mill Cove	Lawrencetown Beach	The Run (between Tangier Island and Baltee Island)
Queensland Beach	Wedge Island to Gaetz Head	Taylors Head Bay
Hacketts Cove	Petpeswick Inlet	Back Beach on Sober Island
Black Duck Cove	Burnt Island to Cuckold Island	West of Sutherland Island
Eastern coast of Marrs Island	Three Fathom Harbour	South and east of Quoddy Hill, extending over to the Eastern Shore Islands Wildlife Management Area
		Shiers Pond to Jake Mosers Point, including MacDonald Island and Torpey Island
		Surrounding Deepwater Island, Table Island, Rack Island, Duck Rock, The Finger, Little Goose Island and Anns Island

Table 7-11: Number and area of estuarine flats at various locations in Units 4, 5 and 6 (Lirette 1988)

Location	Number	Total Area (ha)
St. Margarets Bay	2	138
Prospect	4	1405
Pennant Harbour	1	111
Halifax	3	3663
Cole Harbour	19	627
Lawrencetown	8	405
Chezzetcook	14	841
Petpeswick	6	820
Musquodoboit	22	1708
Jeddore	11	1479
Clam Bay	2	326
Ship Harbour	1	694
Mushaboom	3	513
Sober Island	5	130
Bay of Islands	1	99
Necum Teuch	1	158
Ecum Secum	2	177
St. Mary's River	7	2293

Mud flat sand and mud support little or no rooted vegetation (Smith et al. 1976). However, eelgrass may be found on the lower shore and some cord grass may grow at the first stage of tidal marsh succession (Davis and Browne 1996). Diatoms and filamentous algae occur on the sediment surface and seaweeds are occasionally found attached to stones.

Although the flats support little rooted plant life, they sustain a myriad of micro-organisms (Smith et al. 1976). Microscopic algae and organic detritus from land or adjacent tidal marshes provide most of the energy to the marine flat (Davis and Browne 1996). Large populations of bivalve molluscs (*Mya arenaria*, *Macoma balthica*), amphipods (*Corophium volutator*) and polychaetes (*Spiophanes wigleyi*, *Clymenella torquata*) consume the detritus and its associated bacteria. These animals are adapted to being exposed at low tide and the difficulties associated with living in the mud. Carnivores, and in particular migratory shorebirds, then feed on the detritus-feeding infauna. Common carnivores and scavengers in marine flats include polychaetes (*Neanthes virens*), crustaceans (*Chiridotea caeca*, *Crangon septemspinosus*) and molluscs (*Ilyanassa obsoletus*, *Lunatia heros*).

Some sessile epifauna species such as barnacles and Slipper Limpets can be found attached to small stones on the surface of the mud (Davis and Browne 1996). Several fish species, including flounder, feed on the flats at high tide. In contrast, the flats provide important feeding areas for migratory shorebirds and the occasional mammal (e.g., raccoons) during low tide. Thus various species of birds, fish, molluscs, crustaceans, echinoderms and worms frequent mud flats in Atlantic Canada (Butler et al. 1996).

Threats to flats

Natural threats to mud flats include wave action, snow and ice scouring, storms and hurricanes (Smith et al. 1976). These factors can alter the physical habitat of mud flats. Dredging and infilling can cause physical damage to flats. Raw sewage, industrial wastes, pesticides and insecticides also threaten mud flat environments.

Some mud flats are areas of intense harvesting of worms and clams. These animals turn over the organically-rich substrate of the flats, and in doing so, they aid decomposition by maintaining an appropriate habitat for aerobic bacteria (Smith et al. 1976). Commercial harvesting of these species may have adverse impacts on mud flat habitat. There is also concern that harvesting may disrupt habitat for marine crustaceans which, in turn, would threaten migratory bird populations that feed on them.

Wetland systems

Wetlands are a distinctive group of lands that are saturated with water long enough to promote wetland or aquatic processes (Etherington 1983, Mitsch and Gosselink 1986, NWWG 1988). They are dynamic ecosystems that perform a variety of functions, including (Davis and Browne 1996):

- providing natural filtration and storage of water;
- aiding in flood reduction and control;
- acting as a natural storage base for carbon by absorbing carbon in the form of peat;
- acting as a natural sink for pollutants;
- assisting in stabilizing shorelines and riverbanks thus reducing erosion; and,
- providing wildlife habitat.

Although there are distinctions between the various wetland types, many coastal wetlands occur adjacent to each other. Here, two extensive wetland systems are considered in more detail.

Musquodoboit Harbour

Musquodoboit Harbour (Unit 5) is a long, narrow estuary consisting of a system of intertidal sand and mudflats, with several shallow coastal saline ponds (Environment Canada 2003) (Figures 7-5a and 7-5b). The inner tidal area is protected from the sea by a 5 km long sandspit, fringed in places by salt marsh. The area can be roughly categorized according to various coastal habitat types, of which eelgrass is the dominant component (Table 7-12).

Table 7-12: Coastal habitats of the Musquodoboit Harbour wetland system (Environment Canada 2003)

Coastal habitat	Percent of total area (%)	Area (ha)
Eelgrass beds	30	648
Salt marsh	11	206
Upland islands	21	404
Sand beach, sand and mud flats	17	327
Tidal waters at low tide	17	317
Beach grass (*Ammophila breviligulata*)	1	23

The estuary in Musquodobit Harbour is one of the most important coastal staging sites for Canada Geese (6000 birds) and American Black Ducks (*Anas rubripes*) (3000 birds) (Environment Canada 2003). This area supports the largest wintering population of these two species in Atlantic Canada. The mudflats support extensive eelgrass beds and an abundance of invertebrates, providing food for numerous migratory waterbirds, such as the 3000 Green-winged Teal (*Anas crecca carolinensis*) that use the area during fall migration (Environment Canada 2003). Strong tidal flow into the western arm behind the beach area and the eastern main Musquodoboit River portion keeps the estuary free of ice during the winter and ensures that eelgrass and sand flats are maintained for wintering waterbirds except under the most severe weather conditions.

Numerous staging shorebirds, including the Common Snipe (*Gallinago gallinago*), Short-billed Dowitcher (*Limnodromus griseus*), Least Sandpiper (*Calidris minutilla*), Semipalmated Sandpiper (*C. pusilla*), Greater Yellowlegs (*Tringa melanoleuca*), Lesser Yellowlegs (*T. flavipes*), Spotted Sandpiper (*Actitis macularia*), Black-bellied Plover (*Pluvialis squatarola*), Semipalmated Plover (*Charadrius semipalmatus*) and Ruddy Turnstone (*Arenaria interpres*), also occur during the autumn migration, mainly from late July to September (Environment Canada 2003). The Purple Sandpiper (*Calidris maritima*) frequents the area in winter. Other occasional visitors include the Stilt Sandpiper (*Micropalama himantopus*), Red Knot (*Calidris canutus*), Pectoral Sandpiper (*C. melanotos*), White-rumped Sandpiper (*C. fuscicollis*), Dunlin (*C. alpina*), Hudsonian Godwit (*Limosa haemastica*) and Whimbrel (*Numenius phaeopus*) (Environment Canada 2003).

Natural erosion of the sand dune that protects the western arm from the open ocean is the principal threat to this wetland system (Environment Canada 2003). Development of the surrounding uplands and islands, and construction of houses on privately owned land may also threaten the integrity of the area. Recreational use of the area is high (e.g., swimming, bird watching) and may need to be limited to protect the sensitive ecosystem.

Musquodoboit Harbour was designated a Wetland of International Importance in 1987 (Environment Canada 2003). Parts of this site are project areas under the Eastern Habitat Joint Venture of the North American Waterfowl Management Plan. The management plan for this area will ensure that key habitat sites are protected.

Cole Harbour

The Cole Harbour wetland system (Unit 5) is a dynamic ecosystem (Figure 7-9). This area has a rich history of use that has undoubtedly had an impact on the various habitats of the area. In 1754, the British army endeavoured to settle in the area and encouraged hard-working families to clear the land (Campbell 1979). The challenges faced by these settlers in their attempts to clear the land around the salt marsh were vast. As a result they eventually turned their attention to the salt marsh; if a dyke could be constructed, lush farmland would be available without the toil of clearing the land. The first dyke was built in 1846 but was destroyed soon after by the ocean tides. In 1879, another dyke was constructed in the same area where the first dyke had been. Agriculture began soon after with crops of cranberries and hay. In 1917, fishermen blew up the dyke, thinking that it caused a reduction of salmon stocks within the marsh. Unfortunately, this caused large amounts of sediment from the ocean to be brought into the marsh, narrowing the western mouth of the marsh that emptied into the ocean.

Although the dyke no longer exists, it once affected the physical habitat of the marsh (Campbell 1979). Whereas the opening of the marsh to the ocean had been narrowed, the dyke did not affect the depth of the opening. However, the dyke hindered proper water flow that led to a build-up of sediment in several locations of the harbour.

A railway built in 1912-1914 to join the Eastern Shore to Halifax-Dartmouth cut right across the marsh, thus altering its habitat (Campbell 1979). The railway acted as a dam or dyke, impeding natural water flow and leading to the surging growth of eelgrass throughout the marsh. By encouraging the build-up of sediment, the railway enabled eelgrass to take over the marsh, including areas of important fish habitat. By impeding tidal flushing, the railway also caused the mortality of clams by allowing an increase in freshwater (Smith et al. 1976). Subsequently the thriving clam industry of the 1950s had to be shut down.

The dynamic nature of a wetland system and the impacts of various human activities can greatly affect the habitat delineation of a marsh. This is undoubtedly the case with the Cole Harbour wetland system. Ecological succession, hydrology, sedimentation/erosion, severe weather and human disturbances (e.g., dykes, railroad, clam harvesting) have likely all played a role in determining the distribution of the various habitats within the Cole Harbour wetland site (Austin-Smith et al. 2000). In 2000, the various habitat delineations of 960 ha of the Cole Harbour salt marsh and adjacent areas were verified (Tables 7-13a and b). The area was comprised of 80% estuarine flats and dominated by 69% of eelgrass.

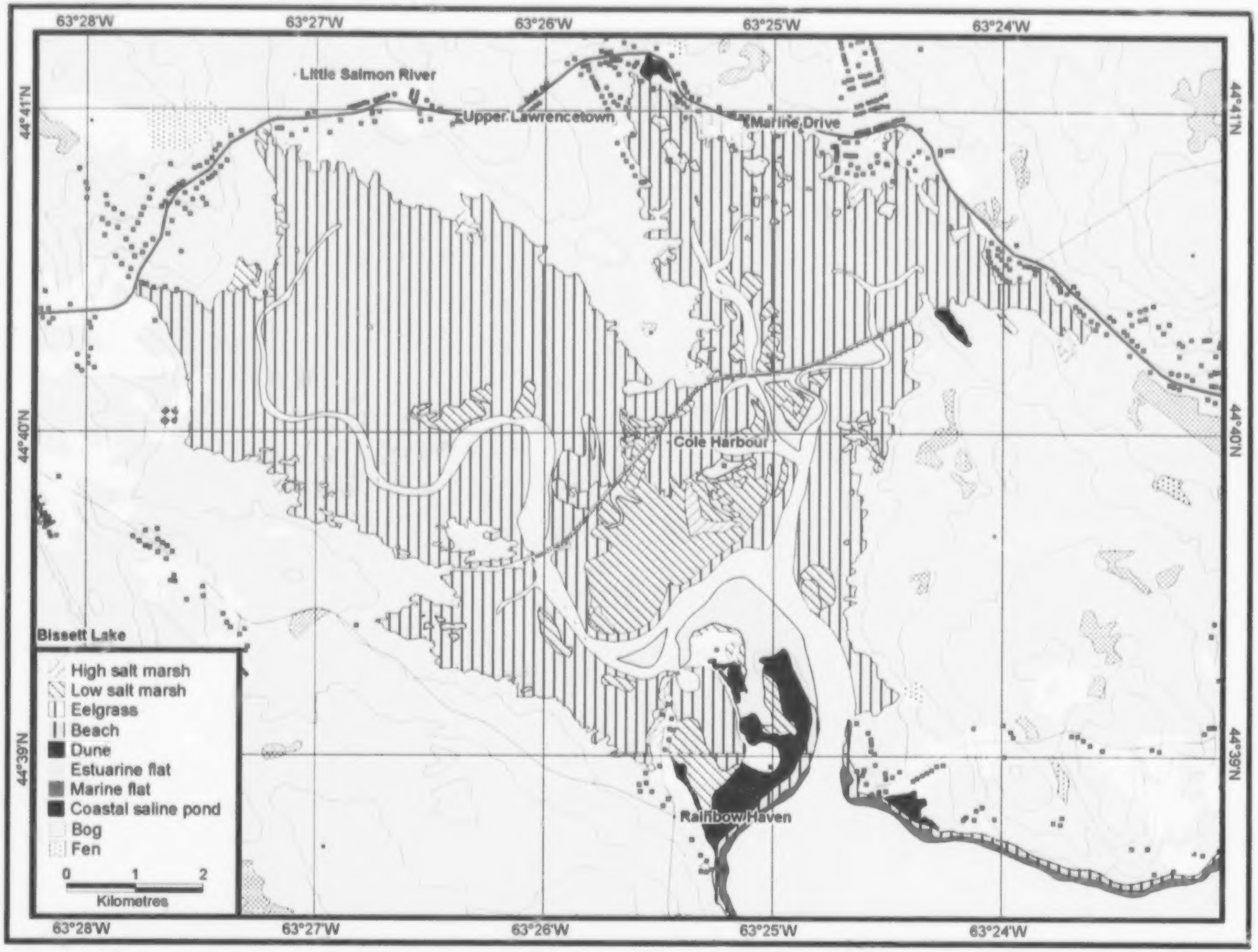

Figure 7-9: Cole Harbour wetlands (Unit 5) (based on data from NSDNR 2002). Basemap layers (NRCan).

Table 7-13a: Area of wetland types in Cole Harbour wetland system (Austin-Smith et al. 2000)

Wetland type	Area (ha)
Dune	18.79
Estuarine flats	765.21
Marine flats	7.34
Ponds	8.78
Salt marsh	158.00
Total	958.12

Table 7-13b: Area of dominant vegetation in Cole Harbour wetland system (Austin-Smith et al. 2000)

Dominant vegetation	Area (ha)
Grass (Marram grass)	18.79
High marsh (*S. patens*)	20.49
Low marsh (*S. alterniflora*)	137.51
Eelgrass (*Z. marina*)	605.14
Total	871.93

The various wetland components of Cole Harbour provide important habitats for many birds. The Cole Harbour site is a significant bird area for the Piping Plover (*Charadrius melodus*), Willet (*Catoptrophorus semipalmatus*) and Great Blue Heron (*Ardea herodias*) (Lock et al. 1994). The Willet depends on salt marsh habitat where it feeds in shallow waters. Only 750 pairs of willets inhabit the Maritime provinces.

Other shorebirds and marsh birds sited in the area include the American Golden Plover (*Pluvialis dominica*), Black-bellied Plover, sanderling (*Calidris alba*), Semipalmated Plover, Greater Yellowlegs, American Avocet (*Recurvirostra americana*), Ruddy Turnstone, Red Knot, Marbled Godwit (*Limosa fedoa*), Least Sandpiper, Spotted Sandpiper, Purple Sandpiper, Pectoral Sandpiper, White-rumped Sandpiper, Dunlin, Common Snipe (*Gallinago gallinago*), Ruff (*Philomachus pugnax*), Short-billed Dowitcher, American Bittern (*Botaurus lentiginosus*), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina),* Little Blue Heron (*Egretta caerulea*), Tricoloured Heron (*Egretta tricolor*) and the Snowy Egret (*Egretta thula*) (Tufts 1986, Fenton 1993, Maybank 1995, Maybank 1996, Maybank 1997, NSBS 2001, CWS 2002, Environment Canada 2002).

Seabirds, including the Herring Gull (*Larus argentatus*) and Great Black-backed Gull (*Larus marinus*), breed in the area (Environment Canada 2002). Cole Harbour is one of the preferred locations of the Canada Goose along Nova Scotia's coast (Lock et al. 1994, Davis and Browne 1996).

The Cole Harbour wetland system is a valued area with a variety of coastal habitats that are used for recreation (e.g., bird watching, swimming, trail walking) and clam harvesting. The area was officially designated the Cole Harbour/Lawrencetown Coastal Heritage Park System in 1998 (Austin-Smith et al. 2000) under the *Provincial Parks Act*.

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Coastal life

8 - Plankton

Although plankton is relatively well studied in the Scotian Shelf area (see Breeze et al. 2002), most research has been focussed on the offshore with comparatively little effort directed to coastal waters falling within SHACI study areas. Of the coastal research, a large proportion has occurred within SHACI Unit 5, making these waters among the best-studied areas along Nova Scotia's Atlantic coast. Long-term and continuous plankton research is conducted by two programs: the Bedford Basin Plankton Monitoring Programme (BBPMP) and the Atlantic Zone Monitoring Program (AZMP). Both programs make regular observations of physical, chemical and biological properties of plankton communities at fixed stations–the former in the Bedford Basin at the head of Halifax Harbour, and the latter at Station 2 on the Halifax Line, located just inside the offshore boundary of SHACI Unit 5. Both the BBPMP and AZMP concentrate on the dominant phytoplankton species, producing rough indices of biological diversity (Harrison pers. comm. 2003, Li pers. comm. 2003).

The AZMP's Station 2 is within 12 nm of shore but conditions there are heavily influenced by offshore and alongshore circulation, and may not be very reflective of the inshore environment. Despite these influences, certain conditions at Station 2 may be similar to those in Bedford Basin. Bedford Basin may have climatologies (Li and Dickie 2001) and average nutrient concentrations (Petrie et al. 1999) similar to the adjacent shelf, and hence, also to Station 2. In addition, there may be close similarities in the annual sequence of recurring biological events between Bedford Basin and the adjacent continental shelf at long time scales (Li and Dickie 2001). Li (pers. comm. 2003) notes that Bedford Basin's standing stock of plankton is likely to be very similar to other coastal environments with similar temperatures. Thus, observations made by these programs may identify trends or events of relevance to many adjacent coastal areas.

In addition to the Bedford Basin, plankton communities have been studied in two other inlets within SHACI Units 4-6 as part of DFO's Phytoplankton Monitoring Program between 1989 and 1994: Ship Harbour and St. Margarets Bay (Keizer et al. 1996). Studies of primary productivity have also been undertaken in several areas within SHACI Units 4-6: Bedford Basin (e.g., Platt et al. 1973, Taguchi et al. 1975, Irwin and Platt 1978a and b, Irwin et al. 1983, Cote and Platt 1984), Petpeswick Inlet (e.g., Platt and Irwin 1972) and St. Margarets Bay (e.g., Platt and Irwin 1968, Therriault et al. 1978).

Phytoplankton

At the base of every food chain there are organisms that transform inorganic materials into organic materials; these organisms are known as primary producers. In the marine environment, most primary production is undertaken through photosynthesis by phytoplankton, the tiny plant organisms floating in the pelagic zone. Benthic or floating algae and macrophytic algae (seaweeds) are also primary producers; however, their contributions to marine primary production are on a lesser scale (Barnabé and Barnabé-Quet 2000).

Phytoplankton range in size from the tiny picoplankton and nanoplankton (0.2-20 μm) (e.g., monocellular coccolithophorids and cyanobacteria) to the microplankton (20-200 μm) which includes the diatoms and dinoflagellates (Barnabé and Barnabé-Quet 2000).

Diatoms are microscopic, photosynthetic marine algae that may live freely in the water or are restricted to surfaces depending on the species and environmental conditions (Landau and Mohn 1997). Diatoms are often the major constituents of the larger phytoplankton, especially in cold temperate waters in both coastal and open sea waters. They reach a maximal photosynthetic depth at between 20-30 m, and may form chains several millimetres long. In coastal waters and lagoons, the genera *Chaetoceros*, *Skeletonema*, *Phaeodactylum*, *Thalassiosira*, and *Nitzschia* dominate phytoplankton populations. Diatoms proliferate in eutrophic waters (Barnabé and Barnabé-Quet 2000).

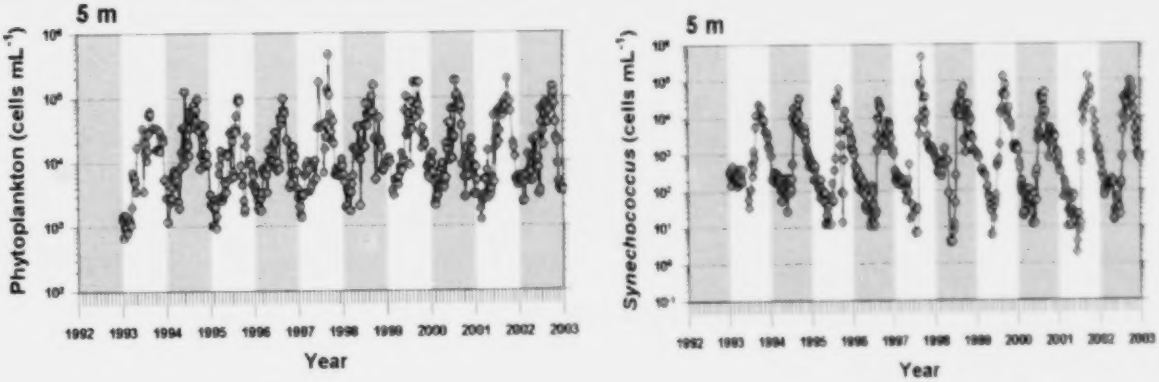
Dinoflagellates are microscopic organisms belonging to the Kingdom Protista. They may be motile or nonmotile, are usually marine, solitary and often photosynthetic (Landau and Mohn 1997). Dinoflagellates (the Peridinians) are somewhat less common than diatoms in temperate waters (Barnabé and Barnabé-Quet 2000).

Many species of phytoplankton are potentially dangerous when large numbers occur in the water as a result of a population explosion or bloom (Landau and Mohn 1997). Phytoplankton may become so concentrated during blooms that waters actually become tinted (e.g. red tides). Blooms will occur when there is enough sunlight to allow for photosynthesis and when there are enough nutrients present in the water to sustain growth and cell division. Toxins produced by phytoplankton may be released directly into the water or may be released during digestion by animals, typically filter feeding molluscs consuming dinoflagellates or diatoms (Landau and Mohn 1997). This phenomenon presents a problem for shellfish aquaculture and shellfish harvesting worldwide.

Generally, coastal waters are much more productive than the open ocean. Primary productivity estimates, based on the carbon content of living organisms, are 500 kg of organic carbon/ha/yr for the open ocean and 1000 kg/ha/yr in coastal waters (Barnabé and Barnabé-Quet 2000).

Phytoplankton of all types and sizes produce photosynthetic pigments, notably chlorophylls and carotenoids. Together, these plankton and their pigments influence the colour and degree of light penetration through the ocean surface. Differences in ocean colour detected by satellite-mounted sensors are interpreted as areas of phytoplankton concentration. Ocean colour in conjunction with sea surface temperature data, are used to estimate primary productivity. The NASA-led Sea-viewing Wide Field-of-view Sensor (SeaWiFS) project was launched in 1997 and has provided information on the Scotian Shelf since September 1997 through to the present. It captures real-time images of chlorophyll concentration on the Scotian Shelf, including coastal areas such as SHACI Units 4-6. Data resolution (at approximately 1.5-2 km/pixel) is presently too coarse for useful interpretation at the scale of SHACI units (DFO 2002a, DFO 2003a).

The BBPMP, which commenced in 1991, is a weekly and perpetual record of the plankton ecosystem in Bedford Basin, providing data to assess environmental variability at the weekly, monthly, seasonal, annual and decadal timescales. This program monitors the cell density, chlorophyll concentration, and in some cases, biomass of several classes of phytoplankton and zooplankton, in addition to other plankton-relevant environmental factors such as nutrients, temperature, salinity, oxygen and fluorescence. Figures 8-1 to 8-3 display cell densities of phytoplankton, bacteria-sized photoautotrophs (*Synechococcus*), chlorophyll *a* and bacteria (heterotrophs) at a series of depths.



(a) (b)

Figure 8-1: Phytoplankton (a) and *Synechococcus* (b) cell densities at 5m depth in Bedford Basin, 1993-2002 (DFO 2003b)

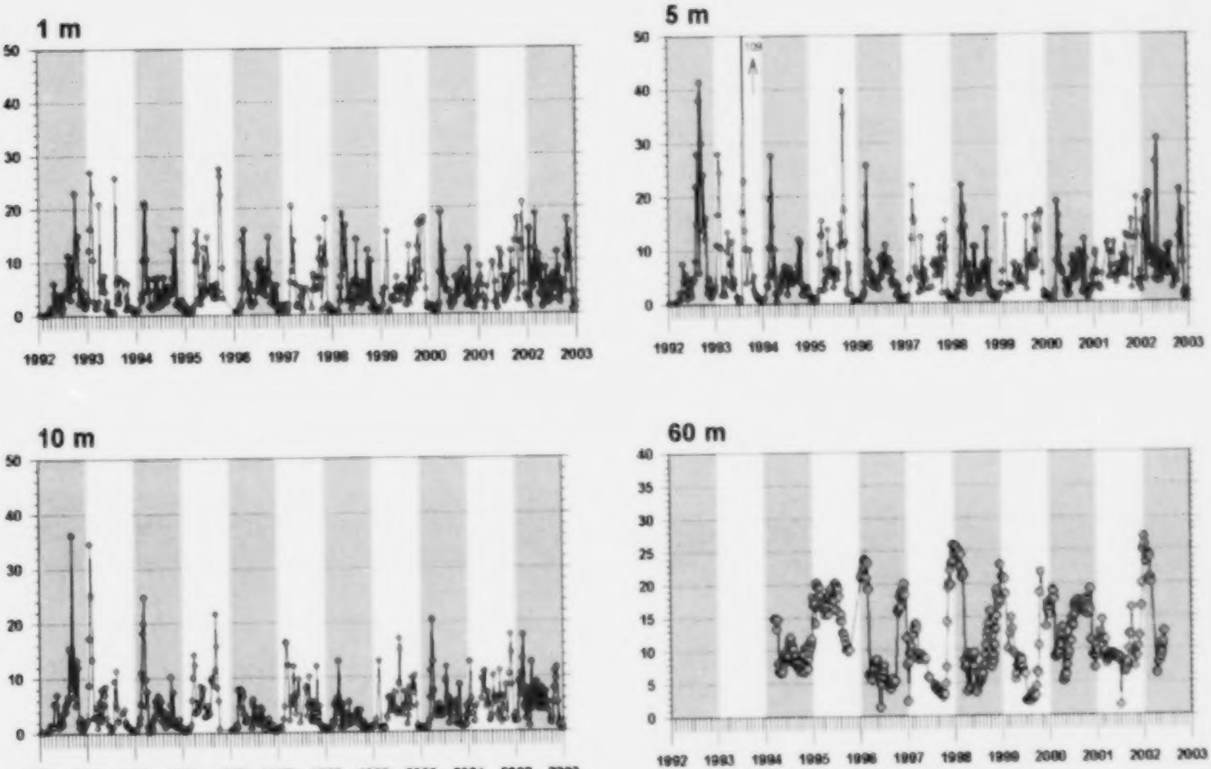


Figure 8-2: Chlorophyll concentration (mg/M^3) measured at 1, 5, 10 and 60 m depth in Bedford Basin, 1992-2002. Chlorophyll measurements at 60 m began in 1994 (DFO 2003b).

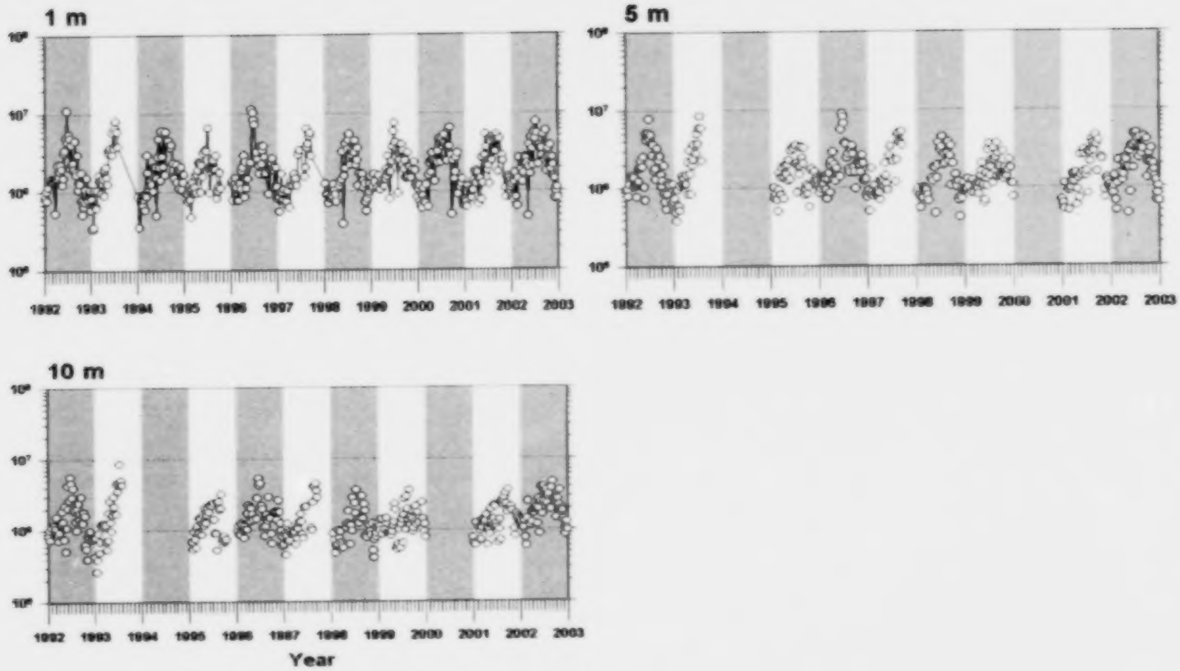


Figure 8-3: Bacteria cell density (cells/mL) at 1, 5 and 10 m depths in Bedford Basin, 1992-2003 (DFO 2003b)

The AZMP has taken depth profiles of chlorophyll *a* at the Halifax Line Station 2 at approximately bi-weekly intervals since 1999. Over 20 samples have been taken per year over each of the first three years. Figure 8-4 is one of these profiles.

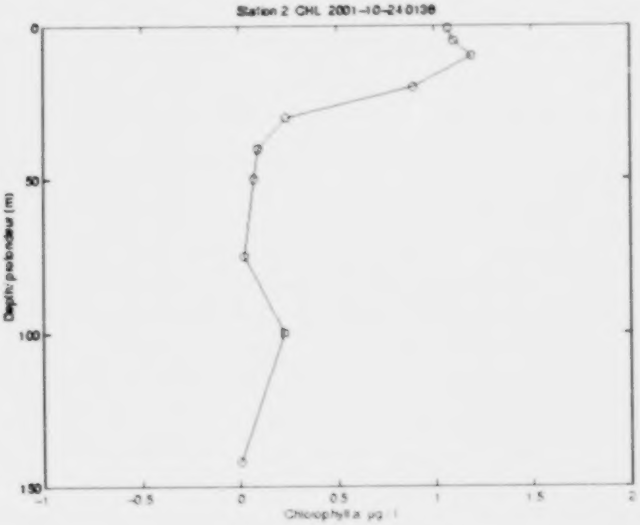


Figure 8-4: Chlorophyll a concentration at Halifax Line Station 2, October 24, 2001 (DFO 2003c)

Individual depth plots were also compiled to give yearly contour plots (Figure 8-5).

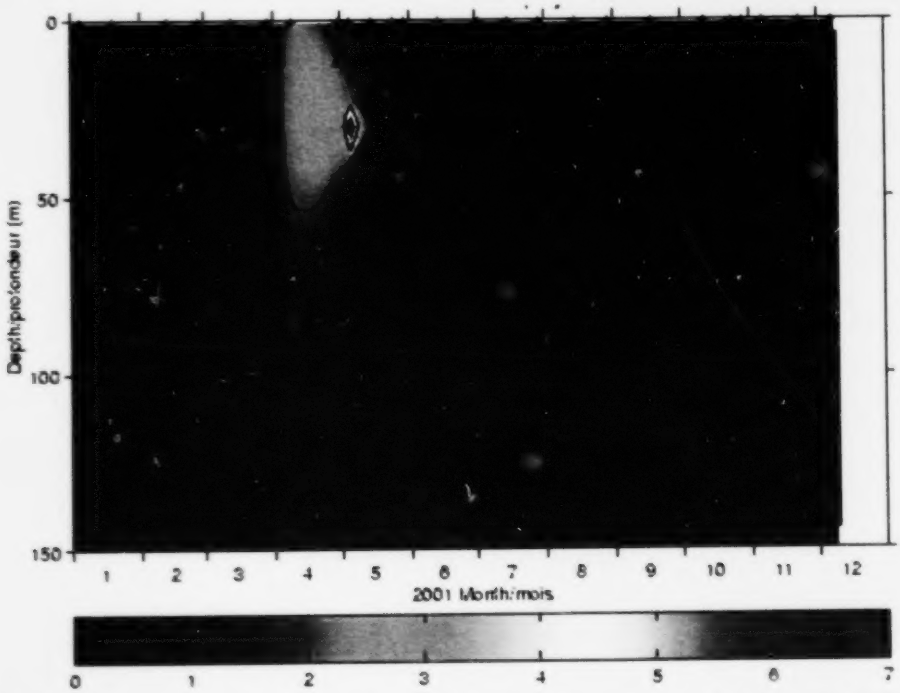
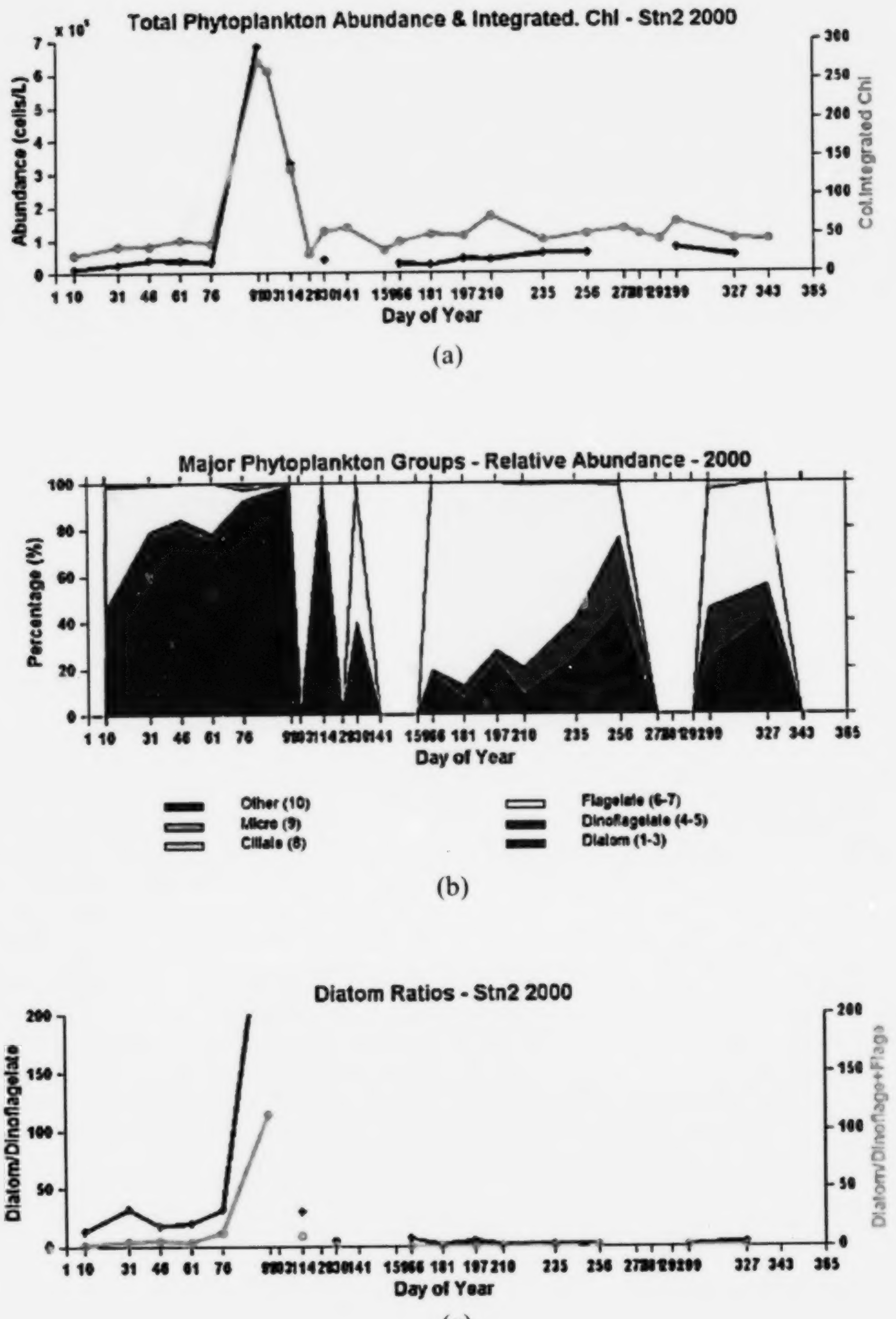


Figure 8-5: Chlorophyll *a* concentration (ug/L) at Halifax Line Station 2, 2001 (DFO 2003d)

The AZMP also determined the absolute and relative abundance of different classes of phytoplankton at Station 2 in 1999 and 2000. The 2000 data (Figure 8-6) reveal several characteristics of phytoplankton abundance during that year. There was one major spring bloom in which total phytoplankton abundance reached over 70 000 cells/L and column-integrated chlorophyll peaked at over 250 mg/m^2. The relative abundance of different phytoplankton groups varied significantly through the year. High initial proportions of diatoms and flagellates changed after approximately month 5 to pronounced flagellate domination with increasing proportions of both diatoms and dinoflagellates throughout the remainder of the year. Comparatively, ciliates, microplankton and other phytoplankton groups were not as abundant throughout the year. It should be noted, however, that some categories of phytoplankton are very small and may be under-represented in microscopic counts.

A less conspicuous and broader fall bloom follows the spring bloom. Overall, phytoplankton biomass, species composition and chlorophyll concentrations were similar in both 2001 and 2000 (P. Lane and Associates 1992, DFO 2002b). The duration and location of spring blooms are variable, demonstrated by a longer and more offshore bloom in 2001 vs. 2000 along the Halifax Line (not shown). In coastal areas, plankton respiration can outstrip oxygen production by primary production by a wide margin, as the coastal ecosystem receives both terrestrial and anthropogenic carbon loads. The biological oxygen demand created by this high rate of respiration can seasonally deplete oxygen concentrations in the water column to levels where fish development, growth and ultimately survival may be compromised (Kepkay et al. 2001).



(a)

(b)

(c)

Figure 8-6: Phytoplankton total abundance (a), relative abundance by major groups (b) and ratio between diatoms and dinoflagellates (c) at Halifax Line Station 2, 2000 (DFO 2003e).

DFO's Phytoplankton Monitoring Program measured the density and *in vivo* fluorescence of chlorophyll *a* between 1988 and 1991/1992 for Ship Harbour and St. Margarets Bay, respectively. The chlorophyll concentrations exhibited maxima in both the spring (March to May) and the fall (September and October), with high concentrations (values frequently exceeding 5 mg/m^3) in bottom waters between April and October (Keizer et al. 1996).

The same program identified and enumerated phytoplankton species from both sites, with a total of 141 species and a range of 1-38 species per sample for each of St. Margarets Bay and Ship Harbour. Of the total phytoplankton species, 27 and 26 potentially harmful species were identified from St. Margarets Bay and Ship Harbour, respectively (Table 8-1) (Keizer et al. 1996). The genera listed in Table 8-1 are known to have species which produce toxic or noxious chemicals or effects although the status of each individual species is not always known.

Table 8-1: Potentially harmful phytoplankton in St. Margarets Bay and Ship Harbour (adapted from Keizer et al. 1996)

Species	St. Margarets Bay	Ship Harbour
Asterionellopsis japonicus	X	X
Alexandrium sp.		X
Chaetoceros (C.) atlanticus	X	X
Chaetoceros concavicornis	X	X
Chaetoceros convolutus	X	X
Chaetoceros danicus	X	X
Chaetoceros decipiens	X	X
Ceratium furca	X	X
Ceratium fusus	X	X
Ceratium tripos	X	X
Diploneis acuminata	X	X
Dinophysis acuta	X	X
Dinophysis caudata	X	
Dinophysis norvegica	X	X
Dinophysis rotundata	X	X
Dinophysis tripos	X	
Dinophysis sp.	X	X
Distephanus sp.	X	X
Euglena sp.	X	X
G. tamarensis	X	X
Nitzschia [Pseudo-nitzschia] delicatessima	X	X
Nitzschia [Pseudo-nitzschia] pungens	X	X
Nitzschia [Pseudo-nitzschia] seriata	X	X
Polykrikos sp.		X
Prorocentrum micans	X	X
Prorocentrum minimum	X	X
Prorocentrum sp.	X	
Scrippsiella trochoidea	X	X
Scrippsiella sp.	X	X

Zooplankton

Zooplankton are tiny organisms that live suspended in the water column and cannot control their overall movement with respect to water currents. For this reason, zooplankton are commonly associated with water masses. Some species are, however, capable of small horizontal movements, or even carry out vertical diurnal migrations up to several hundreds of metres in depth (Barnabé and Barnabé-Quet 2000).

Zooplankton are found in all aquatic ecosystems and play a key ecological role in the marine food web; they are the link between primary producers and larger organisms. Zooplankton are key prey for organisms ranging from small invertebrates to large whales. During some stages in their life cycles, all fish species feed on zooplankton (Breeze et al. 2002). In some areas, the availability of zooplankton is a limiting factor to the success of other species (DFO 2000).

Zooplankton cover a large size range. The small microzooplankton (20 – 200 μm) includes larval and adult stages of small copepods, ciliates, and the larvae of various species of fish and invertebrates. Large zooplankton (>200 μm) includes the adult forms of many copepod species (Barnabé and Barnabé-Quet 2000). The larvae of many fish species are also considered zooplankton while in their planktonic (reduced mobility) phase which occurs prior to entering their more prominent nektonic (actively moving) stage (Barnabé and Barnabé-Quet 2000).

The BBPMP provides the most comprehensive dataset available for zooplankton within SHACI Units 4-6. It describes zooplankton by two parameters: wet weight (g/m2) and density (#animals/m2). Wet weight-described taxa include small, large and total zooplankton (Figure 8-7), as well as the species Aurelia aurita (a jellyfish) and the genus Sagitta (a chaetognath or arrow worm). Density-described taxa include nine individual species or genera of crustaceans; bivalve larvae; small, large and total *Sagitta* species; and members of four other genera. The collection of data on zooplankton began in 1995 or 1996, with the exception of some historical data from the early 1970s (Li pers. comm. 2003, DFO 2003f). In conjunction with these data, Li (2001) notes that the autumn equinox is the time of maximum microzooplankton biovolume, which subsequently decreases to a minimum during the winter months.

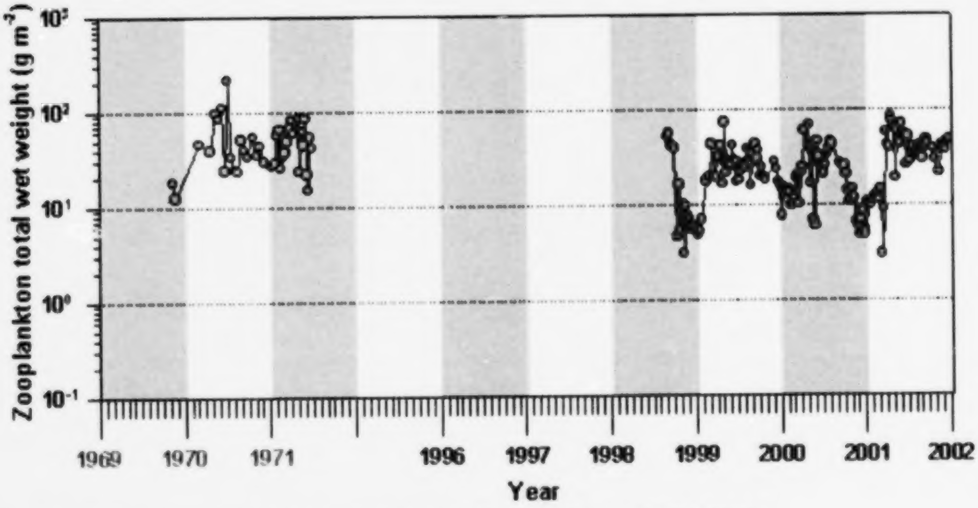


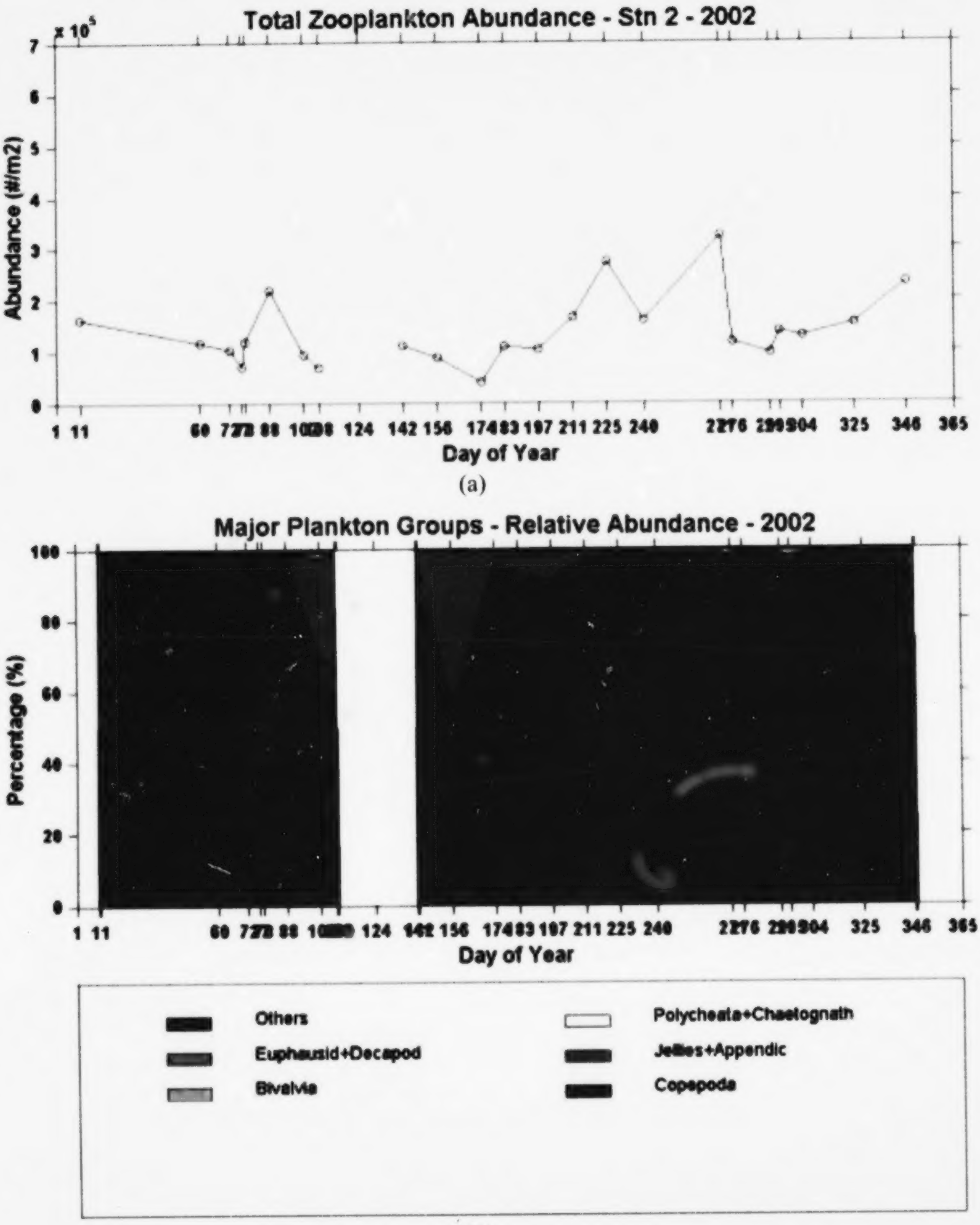
Figure 8-7: Total wet weight of zooplankton in Bedford Basin (DFO 2003f)

Prior to the BBPMP, Sameoto (1971) measured macrozooplankton biomass in Bedford Basin. Sameoto found that five genera of copepods (*Pseudocalanus*, *Oithona*, *Acartia*, *Temora* and *Eurytemora*) made up the bulk of the zooplankton biomass in Bedford Basin, contributing to biomass peaks at various times throughout the year (Table 8-2). There were differences in the species composition and biomass of the copepod community in different parts of the Basin.

Table 8-2: Peak zooplankton biomass periods in the Bedford Basin and their contributing species (based on data from Sameoto 1971)

Peak	Contributing species
May	*Pseudocalanus*
Early July	*Acartia* and *Pseudocalanus*
September	*Pseudocalanus*, *Acartia* and *Oithona*
November	*Acartia*, *Pseudocalanus* and to a lesser extent *Eurytemora*

The AZMP also collects data on zooplankton abundance. These data indicate that copepods are the most abundant of the zooplankton (Figure 8-8) (DFO 2004). *Oithona* spp. are the most abundant copepods (Figure 8-9), generally constituting approximately 40% of the total copepod abundance but less than 10% of the biomass because of their small size (Head and Harris 2004). The abundance of various *Calanus* spp. along the Halifax Line is given in Table 8-3. *Calanus finmarchicus*, *C. glacialis and C. hyperboreus* are commonly found in the near-surface layers of the Scotian Shelf during spring and early summer and in deeper water in the shelf basins during fall (Sameoto and Herman (1990, 1992). *Calanus finmarchicus* is the dominant species over the southwestern Scotian Shelf, and *C. glacialis* and *C. hyperboreus* are more important in the northeast (Sameoto and Herman 1992). The springtime source of *Calanus* on the eastern Scotian Shelf is the populations overwintering in the Gulf of St. Lawrence which arrive via the Cabot Strait (Sameoto and Hemran 1992, Head et al. 1999). In contrast, the source of *C. finmarchicus* for the central and western Scotian Shelf regions appears to be a population that overwinters in the deep ocean beyond the shelf break (Head et al. 1999). These and many other zooplankton are thought to exhibit strong seasonal cycles in response to phytoplankton growth.



(a)

(b)

Figure 8-8: Total zooplankton abundance (a) and relative abundance of major plankton groups (b) at Station 2 of the AZMP (DFO 2004a).

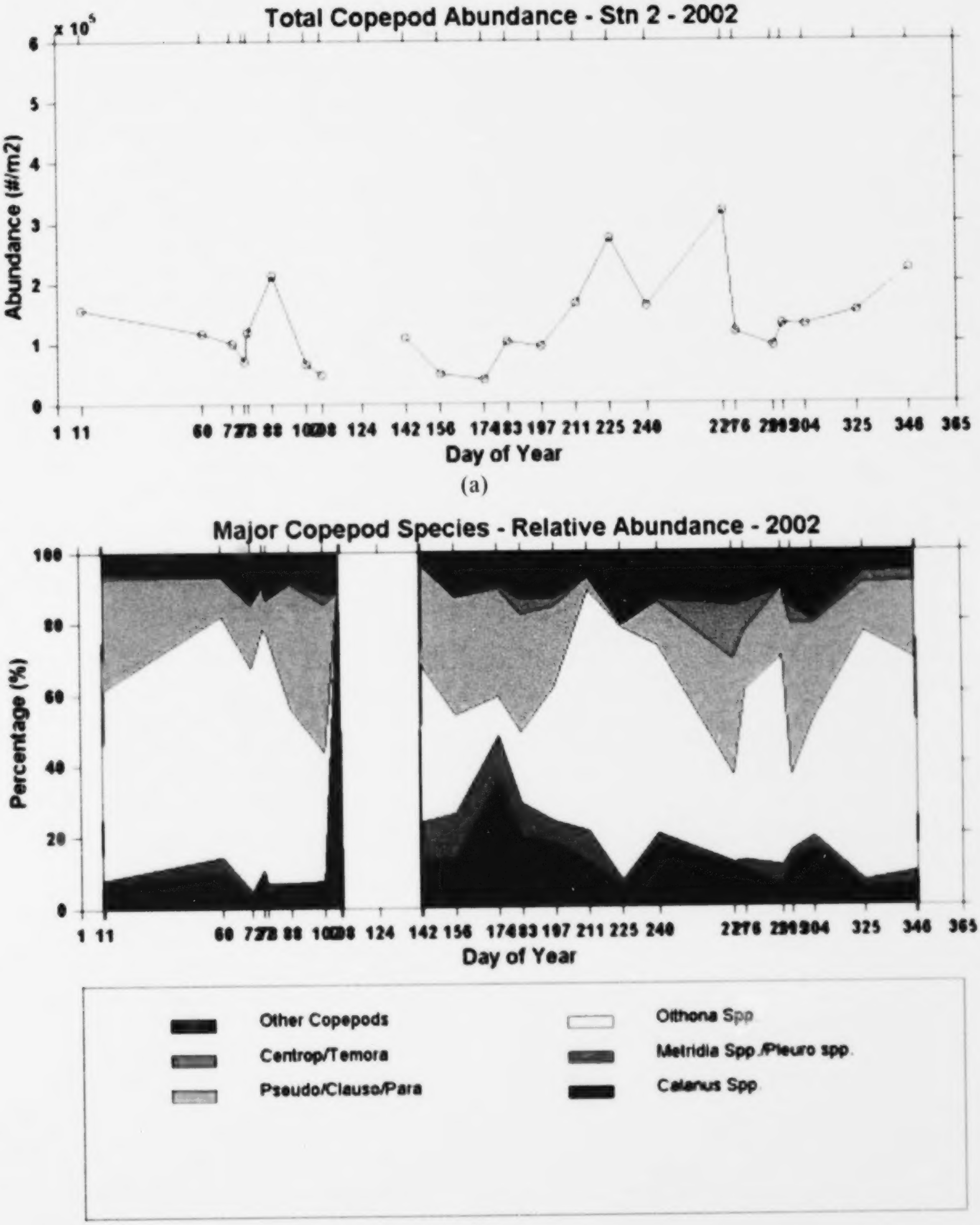


Figure 8-9: Total copepod abundance (a) and relative abundance of major copepod species (b) at Station 2 of the AZMP in 2002 (DFO 2004b)

Table 8-3: Abundance (individuals/m^2) of *Calanus* spp. at stations 1 and 2 on the Halifax Line in April 1995 and April 1997 (adapted from Head et al. 1999).

Station	*C. finmarchicus*		*C. glacialis*		*C. hyperboreus*		Total *Calanus*	
	1995	1997	1995	1997	1995	1997	1995	1997
1	2 014	108	2 909	414	22 722	27 305	27 644	27 827
2	6 875	44 475	4 552	2 011	13 390	18 125	24 817	64 611

Zooplankton biomass has also been measured in St. Margarets Bay. Sameoto and Jaroszynski (1972) found that the biomass of copepods in St. Margarets Bay increased steadily from May to September/October, following which there was a regular decline until February. The biomass was relatively constant from February to May. In the spring the biomass was higher offshore than in the Bay but during the fall copepod peak it was slightly lower offshore. From June to November copepod biomass decreased with depth but from January to May the biomass tended to increase with depth. On occasion the biomass of copepods within the Bay was found to be significantly different from that outside the Bay. Thus, copepods were abundant in the Bay during the summer and fall, with the lowest copepod biomass and production occurring in the winter and spring months.

Paranjape and Conover (1973) found that high peaks in biomass of total zooplankton in St. Margarets Bay in July and August in 1968, and August and September in 1969 and 1970 were dominated by the copepods *Pseudocalanus minutus* and *Temora longicornis*, while *Centropages typicus* and a species of pteropod, *Spiratella retroversa*, contributed to November 1969 and 1970 peaks. The biomass was consistently higher outside the bay in the early summer months but lower in the fall and winter. Copepods of six genera (*Calanus*, *Pseudocalanus*, *Temora*, *Acartia*, *Centropages* and *Oithona*) were present throughout the year, together comprising 75-99% of the total sample in most seasons, with the exception of the midsummer and early fall when they reached as low as 50% or less (Table 8-4). During these periods, Cladocera (types of copepod) and pteropods were next in abundance, respectively. Copepod crustaceans were the most abundant group numerically in the bay and thus were the largest contributors to the zooplankton volumes in most seasons.

Table 8-4: Percentage of various copepods in the total zooplankton population within St. Margarets Bay (based on data from Paranjape and Conover 1973)

Species	Percentage of total zooplankton population (%)	Peak abundance
P. minutus	32	August/September
Oithona similis and *O. setigera*	25	July/August*
T. longicornis	13	July/August
Centropages typicus	8	August-December
Calanus spp. (primarily *C. finmarchicus*)	4-7	May/June
Acartia clausi and *A. longiremis*	4	July/August

*secondary maxima were recorded in late winter months

Species composition of copepods in St. Margarets Bay was similar to that of Bedford Basin (Sameoto 1971). A major difference, however, was the low numbers of *Calanus* spp. found in the Basin as compared to the Bay. In addition, there were much lower densities of the euphausiids *Thysanoessa rashii* and *T. inermis* in the Basin and an absence of euphausiid larvae as compared to St. Margarets Bay during the summer. The major difference in the macrozooplankton was the absence of the mysids, *Mysis mixta* and *Erythrops erythrophthalma*, amphipods and shrimps that were abundant in St. Margarets Bay.

The dominance of copepods in the total zooplankton and the presence of 5-6 copepod genera accounting for the majority of all copepods in Bedford Basin and St. Margarets Bay are similar to results in other coastal areas (e.g., Fish and Johnson 1937, Deevey 1956, Legaré and MacLellan 1960, Sage and Herman 1972) although the dominant species present are not necessarily the same. Thus the same may be true of other coastal environments in SHACI Units 4-6.

The lack of information about the abundance, distribution and variability of phytoplankton and zooplankton within the coastal region limits our ability to identify important areas for either of these groups. In addition, primary productivity estimates generated by SeaWIFS and AZMP data are estimates of gross primary productivity (the total amount of biogenic carbon production). Kepkay et al. (2001) emphasize the importance of determining the net primary productivity which is the amount of carbon made available to the ecosystem after subtracting the amount consumed by plankton respiration from gross production. In coastal environments, net primary production is often supplemented with terrestrial carbon loading, requiring consideration of sedimentary biological oxygen demand and photochemical oxidation in addition to the above. Currently, data on net productivity within local coastal environments is absent or scarce, although DFO, Environment Canada and other partners have proposed a research program to address the issue (Kepkay 2001).

Coastal plankton issues

Harmful phytoplankton

Several species of phytoplankton are considered harmful. Noxious phytoplankton blooms, often called red tides because they change the colour of water, can directly kill fish, birds, and mammals (including humans). Noxious blooms can also cause indirect die-offs by altering the environment to create unfavourable conditions (e.g. hypoxia, reduced food quality, light limitation) (Ruiz et al 1999). Nutrient loading and the resulting increased eutrophication of estuaries can influence noxious phytoplankton blooms (Smayda 1990).

In this region there are three known types of poisoning caused by toxic phytoplankton blooms: Paralytic Shellfish Poisoning (PSP), Diarrhetic Shellfish Poisoning (DSP), and Amnesic Shellfish Poisoning (ASP).

PSP is caused by the dinoflagellate *Alexandrium*. The toxins produced by this species are concentrated in the digestive organs, siphon, and gills of filter feeding molluscs like scallops, oysters, mussels and clams, but the toxins do not harm the molluscs. Filter feeding fish may also concentrate the toxins. Unlike molluscs, however, the toxins are lethal to fish. In the North Atlantic, *Alexandrium* is found from New England through to Canada, and in the United Kingdom. Paralytic shellfish poisoning (PSP) toxins exceeding regulatory action limits were first identified off Halifax in 1992, and have been identified every year since, at least until 1997

(Bates 1997). Although permanently closed to shellfish harvests due to coliform bacteria, recreational mussel harvesting has occurred there, resulting in illness.

The dinoflagellates *Prorocentrum* and *Dinophysis* are known to cause DSP through the production of okadaic acid (OA). DSP is found worldwide and is associated with bivalve molluscs (Landau and Mohn 1997). In the Bedford Basin, record high concentrations of *Dinophysis norvegica* were recorded in the first ever DSP red tide associated with *D. norvegica* in eastern Canada during the summer of 1990 (Subba Rao et al. 1993). Although not consumable for bacterial reasons, scallops from the Bedford Basin were examined and found to have accumulated the OA, but depurated slowly. Subba Rao and others (1993) concluded that DSP episodes could potentially occur in other Nova Scotia waters should similar toxicogenic growths of *D. norvegica* occur in areas with consumable molluscs. Diarrhetic shellfish poisoning has forced the closure of shellfish harvesting areas in St. Margarets Bay in the past, and low levels of DTX-1, a DSP toxin, have been found in cultured mussels originating in Ship Harbour (Bates 1997).

ASP is caused by the diatom *Pseudo-nitzschia multiseries*. Under certain conditions, this species will produce high levels of domoic acid. The specific conditions required for natural blooms to become dangerous are unknown. *Pseudo-nitzschia*, and other related diatoms that produce domoic acid, are widespread along the Atlantic coast of North America (Landau and Mohn 1997).

In November 1987, there were several incidences of domoic acid poisoning in the Maritimes, four of which resulted in death. The people affected ate blue mussels grown in aquaculture that had been exposed to a bloom of the toxic diatom *Pseudo-nitzschia multiseries*. In addition to the serious human health issues associated with toxic phytoplankton, noxious blooms can also cause significant losses for shellfish industries. Poisoned shellfish cannot be sold, thus the growers, restaurants and fish markets also suffer as a consequence (Landau and Mohn 1997).

In response to incidences of shellfish poisoning in Atlantic Canada, DFO set up a phytoplankton monitoring program between 1989 and 1994 to survey Atlantic Canada's coastal waters to determine what potentially harmful species of phytoplankton were present. Four of the five Nova Scotia monitoring sites were located along the Atlantic coast: Whitehaven Harbour, Ship Harbour, St. Margarets Bay, and Woods Harbour. In total, 31 species of potentially harmful species were present (Keizer et al. 1996).

Species introductions through ballast water

Ships take up ballast water in ports to ensure the safe handling of vessels on the open sea and for manoeuvring into ports. Ballast water and associated sediments are linked to the transport and transfer of non-indigenous species to and from ports in various regions of the world (Martin et al. 2002). Phytoplankton and zooplankton, as well as the larval forms of larger marine species may be transported in this manner. Relating specifically to phytoplankton, the transport of toxic species through ship ballast has been implicated in the increased frequency of proliferations of toxic phytoplankton (Barnabé and Barnabé-Quet 2000). Ballast water exchange is currently permitted along the Atlantic coast of Nova Scotia (Petrie pers. comm. 2003), and therefore species introductions from outside ports could occur in HRM waters. This is particularly true of Halifax Harbour, which receives thousands of ships annually visiting from foreign waters and ports. Smith and Kerr (1992) concluded that introductions of exotic phytoplankton via ballast water threaten Canada's marine ecosystems, particularly in Atlantic Canada. More information on this topic is provided in the section on Marine Bioinvasions

Aquaculture

The introduction of species through ballast water can pose serious threats to aquaculture operations. As mentioned, toxins in phytoplankton can be concentrated to harmful levels in filter feeding invertebrates such as blue mussels. Ballast water is a potential vector for these toxic species. For example, the Magdalene Islands are a major mussel producing area in the Gulf of St. Lawrence that was historically free of phycotoxin-producing marine algae. The introduction of *Alexandrium* spp., a potentially toxic dinoflagellate, in ship ballast from the St. Lawrence estuary has, however, threatened aquaculture in this area (Gosselin et al. 1995).

Local threats to plankton

There are several possible threats to plankton populations worldwide that may be locally relevant along the Atlantic coast of Nova Scotia. Any threat that induces a change (be it an increase or decrease in population size, or a change in species composition) in plankton populations is potentially quite significant to the greater ecosystem because plankton is at the base of the food chain. Changes that are detrimental to plankton are potentially detrimental to invertebrates, fish, birds and marine mammals.

Oil spills and pollution

An oil spill, blowout, or the chronic release of oil into the marine ecosystem could have several effects on both phytoplankton and zooplankton. Oil and other pollutants have been demonstrated to cause the replacement of relatively large species of phytoplankton by smaller species, as is occurring in the North Sea (Howarth 1981, Fisher 1976). This type of shift could induce a change in the animals further up the food chain and possibly even lead to the replacement of top carnivores in the ecosystem (Greve and Parsons 1977). Such a change could have serious consequences for local fisheries.

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9 - Marine plants

Marine plants refer to both seaweeds (macroalgae) and angiosperms (flowering plants) that are found in marine habitats. The primary producers in coastal areas include phytoplankton, seaweeds (macroalgae) and marine grasses (eelgrass, salt marsh grass and marram grass) (Berrill and Berrill 1981). Phytoplankton was discussed in a previous section of this document, and the marine grasses are discussed in the Coastal Wetlands section. This section will therefore focus on seaweeds.

Distribution and habitat

Seaweeds are marine and brackish water macroalgae that are attached at some time in their lives, and come in three basic colours (brown, red and green), although there is dramatic variation in the actual colours displayed by individual organisms (NUIG 2003). Green seaweeds are predominantly freshwater and terrestrial, whereas red and brown algae are mostly marine; species of the latter colour classes comprise almost all seaweeds found in SHACI Units 4-6. However, green seaweeds are a large component of the biomass of seaweeds in sheltered marine habitats receiving inputs of nutrients from lagoons and estuaries (Sharp pers. comm. 2005). Irish moss *(Chondrus crispus*) and crustose coralline algae (*Corallina officinalis* and *Lithothamnium* spp.) are the most common red algae along HRM shores, the former occupying exposed areas in the lower intertidal and upper subtidal zones, and often found in association with kelps (*Laminaria* spp.) (P. Lane and Associates 1992). Coralline algae form pink stony crusts on rocks and occur at the deepest depths of any algae, 80-100 m in clear water (Davis and Browne 1996).

Brown algae are exclusively marine and dominate the biomass of seaweeds found in intertidal and shallow subtidal zones of hard-bottom shores, particularly in areas exposed to wave and surf action but also in tidal marshes and on stones on muddy shores (Davis and Browne 1996). Of the 109 Maritime species of brown algae, rockweed (*Ascophyllum nodosum*) and *Fucus* species share dominance of the intertidal zone, attaching themselves to rocks or bedrock with a holdfast (DFO 1998). Rockweed and fucoids occur in a wide range of wave exposures, but *A. nodosum* dominates sheltered areas, whereas *Fucus vesiculosus* and *F. spiralis* dominate more exposed locations and hence most of the intertidal zone in the Halifax area (Moore et al. 1986). These species are replaced by *Chorda* spp. and filamentous brown algae on sand/gravel bottoms, by *C. crispus* on rocky bottoms and by *Zostera marina* (eelgrass) on muddy bottoms (P. Lane and Associates 1992). East of Halifax, the rockweed resource tends to be in sheltered bays and estuarine locations that are frequently urbanized and industrialized. Individual plants found along HRM shores are typically shorter, and the biomass of rockweed beds is smaller than those found in southwest Nova Scotia. The intertidal zone here is also much narrower, at only a few metres wide (Sharp 1986, DFO 1998).

Large brown seaweeds collectively known as kelp dominate the subtidal macroalgae flora. Kelp is most commonly found on rocky bottom areas with high wave energy, and is only occasionally found within the lower intertidal. Kelps are also found in areas of relatively low wave energy. They require good water circulation and can exist in backwaters if there are tidal rapids (Sharp pers. comm. 2005). The most abundant kelp species of SHACI Units 4-6 are *Laminaria* *longicruris, L. digitatus, Agarum clathratum, A. cribrosum, Alaria esculenta and Saccorhiza dermatodea* (P. Lane and Associates 1992), although a number of other species may replace or mix with those listed above in certain situations. These less common species include *Polysiphonia urceolata, P. elongata, Rhodomela confervoides, Phyllophora pseudoceranoides, Desmarestia viridis, D. aculeata, Corallina officinalis, D. viridis, Odonthalia dentata, Dilsea integra* and *Palmaria palmata* (Novaczek and McLachlan 1989).

Surveys of Nova Scotia's Atlantic coast (Moore and Miller 1983, Moore et al. 1986) indicate that over 80% of macrophyte habitat areas were found adjacent to highly exposed locations. This association is very strong, as highly exposed locations account for only 25% of the shoreline between Ship Harbour (Unit 6) and Cape Sable Island (Unit 2). Relatively little rocky subtidal habitat is found between Ship Harbour and Ecum Secum; although this shoreline comprised 18% of the total surveyed area, only 7% of rocky habitat was found along its length (Moore et al. 1986).

Intertidal zone

Seaweed distribution is defined by several shoreline characteristics, including the vertical position along the intertidal and subtidal slope, the exposure to wave action, and shore steepness. Novaczek and McLachlan (1989) recognized three biotic zones within the intertidal, each dominated by a distinct seaweed assemblage. In descending vertical order, the littoral fringe is dominated in season by species including *Enteromorpha, Porphyra, Ulothrix, Prasiola, Urospora*, cyanophytes and lichens. The midlittoral zone was dominated by 80-100% cover of fucoid species (*Fucus spiralis, F. vesiculosis, F. evanescens* or *F. serratus*), ranging from the upper barnacle line at the top to the upper kelp line at the bottom. The sublittoral fringe is defined by kelp species, although they are not always present intertidally. Depending on conditions, Irish moss, fucoids or ephemeral species could dominate or co-dominate this zone (Novaczek and McLachlan 1989). *Fucus* spp. tend to dominate if there is significant ice scour (Sharp pers. comm. 2005). Novaczek and McLachlan (1989) also defined the vertical limits of common seaweeds along the Atlantic shore (Table 9-1), noting that the upper limits on many intertidal species are higher on steep wave-exposed shores. In contrast, *Fucus* species occupy the lower intertidal region on sheltered sites on the Atlantic coast, thereby experiencing lower vertical limits in these areas than within similar areas in the Bay of Fundy (e.g., Pringle and Mathieson 1986).

Table 9-1: Vertical limits (m from chart datum) of common macroalgae distribution along Nova Scotia's Atlantic shore (Novaczek and McLachlan 1989)

Seaweed	Upper limit	Lower limit	Range
Fucoids	+ 1.7	- 1.3	3.0
Chondrus crispus	+ 1.0	- 3.6	4.6
Kelp species	+ 0.1	- 9.3	9.4
Agarum	- 7.3		
Phyllophora spp.	- 4.3		

Subtidal zone

Subtidal seaweeds characteristic of SHACI Units 4-6 include *L. longicruris, L. digitata, A. esculenta, S. dermatodea* and *A. cribrosum*, in descending vertical order (P. Lane and Associates 1992, Davis and Browne 1996). They are distributed across three vegetation belts that characterize the subtidal zone: a Laminaria-Desmarestia belt from approximately mean local sea level to about 15 m depth; an Agarum-Ptilota belt below 10 m; and a Phyllophora-Polysiphonia belt below 30 m (Edelstein et al. 1969, Chapman 1986). Novaczek and McLachlan (1989) note that *Callophyllis cristata, Phycodrys rubens* and *Phyllophora* spp. were also common in this latter zone. Mann (1972) indicated that the Laminaria-Desmarestia belt is particularly dense, shared between *L. longicruris* and *L. digitata*. The canopy of wave-exposed Atlantic sites is often 90-100% dominated by *Laminaria* and *Desmarestia* species, and the lower limits of kelp on the outer Atlantic coast only occur on rock at depths >15 m or is otherwise defined by unstable bottom or sea urchin aggregations (Novaczek and McLachlan 1989). *Codium fragile* spp. *tomentosoides*, an invasive green alga, may have changed the pattern of distribution of marine plant communities in certain areas, such as Prospect and St. Margarets Bay where dense stands of *Codium* have been observed (Davis and Browne 1996, Benthic Ecology Lab 2001).

Green sea urchins (*Strongylocentrotus droebachiensis*) are the dominant seaweed grazer along Nova Scotia's Atlantic coast, and they are part of a dynamic abundance cycle with kelps in the Laminaria-Desmarestia belt, with dominance alternating between the macroalgae and sea urchins. *Laminaria* species typically dominate *Desmarestia* species until high urchin abundance reduces the populations of both species. *Desmarestia* quickly colonize the habitat as urchins die off, relinquishing dominance to *Laminaria* one or more years after the last urchin peak (Chapman 1986).

Five of eight kelp species surveyed during the 1980s occurred more frequently with low sea urchin density (Table 9-2), and the remaining surveyed species, coralline algae, *A. cribrosum* and *S. dermatodea*, occurred with frequencies of 7-12% and were equally common with high and low urchin densities. *Alaria esculenta* was found deeper where urchin densities were low but higher urchin densities confined it to shallow and exposed locations which serve as refuges from urchin grazing for all seaweeds (Miller 1985, Moore et al. 1986). *Alaria esculenta* is the first kelp species in the sublittoral fringe (Sharp pers. comm. 2005).

Table 9-2: Change in seaweed abundance and distribution with increasing urchin density (Moore et al. 1986)

Species	Low urchin density	High urchin density
Laminaria longicruris	56%	36%
Laminaria digitata	19%, found at less exposed sites	9%
Fucus spp.	31%, deeper and more sheltered sites	5%
Chondrus crispus	29%, deeper and more sheltered sites	4%
Filamentous algae	72%	51%

Population status and growth

The wide availability of suitable rocky bottom and adequate wave energy make the Atlantic unit among the most significant areas of seaweed growth and productivity in the province (Moore et al. 1986). This growth is tempered, however, by the seasonal and regional availability of nitrate, a key seaweed nutrient. Nitrate is relatively scarce during summer months, and accordingly most macroalgal productivity occurs during spring and fall, following local plankton blooms (Sharp 1986). The effect of this nutrient depletion is to uncouple seasonal growth patterns from seasonal variations in light availability and photosynthetic assimilatory rates (Chapman 1986).

The productivity and population status of seaweeds within SHACI Units 4-6 is not well known, as no one conducts comprehensive surveys of bed area or biomass east of Halifax. Cousens (1981) calculated the biomass density of rockweed at St. Margarets Bay as 96 ± 45 t/ha, among the highest levels in the world (Sharp 1986). On a broader scale, the total standing rockweed crop between Medway and Chedabucto Bay was estimated at 154 000 wet tonnes using a combination of surveys, spot biomass values and air photo analysis. The estimated harvestable annual yield for the same area was estimated at 11 500 wet tonnes (Sharp 1986).

Even less is known about the local productivity of Irish moss. The prevailing Irish moss beds along the Eastern Shore are found roughly within SHACI Unit 6, and Michanek (1975) estimated the total biomass of these beds at 115-450 tonnes. In Nova Scotia, there have been reports of Irish moss losing its red colour and becoming bleached. Bleaching has been observed in south west Nova Scotia in the late 1980s and in the Halifax area in the late 1990s (Sharp pers. comm. 2005). The cause has not been investigated but similar events have been reported by Dudgeon (1990) in Maine and attributed to freezing. Recent experiments with UV effects on settlement and photosynthesis point to another possible cause (Lotze et al. 2002). In the Bay of Fundy there has been a decline in the diversity of red seaweeds which has been related to some anthropogenic inputs (Bates et al. 2001).

Laminaria longicruris, the dominant local kelp species, is the best-studied macrophyte in SHACI Units 4-6. Chapman (1986) documented considerable variation in the densities of *L. longicruris* populations in Nova Scotia; areas of high plant density showed lower plant mass, and areas with lower plant density showed higher individual plant masses. Chapman (1986) reviewed previous works to estimate the average biomass of *L. longicruris*-dominated seaweed beds on Nova Scotia's Atlantic shore between 3.5 and 5.5 kg/m^2. St. Margarets Bay is an exception to this trend with estimates up to 11.5 kg/m^2 (Mann 1972). Published estimates of *L. laminaria* productivity from within the Bay have varied widely, ranging from 143-428 gC/m^2/yr (Hatcher et al. 1977) to 2000 gC/m^2/yr (Mann 1972). The reasons for discrepancies among these estimates are unknown.

Harvest

Seaweed harvesting is a very minor industry within SHACI Units 4-6, although it is conducted by both commercial and recreational interests to a limited extent (Sharp pers. comm. 2001, Weber pers. comm. 2003). DFO regulates the marine plant harvest in Nova Scotia by issuing open access annual harvest licenses that permit unlimited harvest of marine plants to unrestricted harvest areas throughout Nova Scotia. The province has issued exclusive rockweed harvest leases at only three locations in SHACI Unit 4: Chebucto Head, Sambro Harbour and Prospect

Bay (Huston pers. comm. 2003). Other than these areas, the HRM coastline is completely open to competitive harvesting. No one monitors the actual harvesting effort of individual harvesters but Weber (pers. comm. 2003) and Huston (pers. comm. 2003) estimate this to be relatively low along the HRM shoreline. Only 37 marine plant licences have been issued for use in the regulatory unit overlying SHACI Units 4-6 (Marine Plants Harvesting District 11, stretching from Lunenburg County to Chedabucto Bay), versus over 900 issued in District 10 (between Shelburne County and Minas Basin). Harvesting is only permitted between July 31 and October 31 of each year (Sharp 1986).

Rockweed harvesting within SHACI Units 4-6 only began commercially in 1992 and by 1995, landing sites had been established in five bays. As of 1998 the most viable harvest areas were in use, but total annual landings had not exceeded 1000 tonnes and were not expected to do so (DFO 1998). None of these landing sites remain in use today and landings have dropped significantly since 1998 (Sharp pers. comm. 2001). Holdfast content in the harvest is low, at 2.7% (SD ± 4.6%). Because few exclusive licenses exist in this area, over-harvesting remains a possibility (DFO 1998).

The harvest of Irish moss within SHACI Units 4-6 is very poorly known. DFO's 1989 marine plants fishery management plan shows no major harvesting areas for this species, and Caddy and Chandler (1976) reported a very small but stable harvest in four areas: St. Margarets Bay, off Chebucto peninsula, in Clam Bay and off Liscomb Point. In the 1960s one processor was buying Irish moss out of Prospect (Sharp pers. comm. 2005). In the past three years there have been requests from harvesters in southwest Nova Scotia to use their licenses in southern Nova Scotia. The demand for Irish moss is up, as is the price, and the harvest is spreading from the south to the east on this coast (Sharp pers. comm. 2005).

A very limited (100 tonne) storm toss kelp harvest also occurs near Hartlen Point, Halifax Harbour, with just two DFO licenses issued (Huston pers. comm. 2003).

Significant areas

Chapman (pers. comm. 2001) and Scheibling (pers. comm. 2001) identified three areas within SHACI Unit 4 as potentially significant for marine plants, and none in either Unit 5 or Unit 6. These areas are St. Margarets Bay, Chebucto Peninsula and the Central Coast.

St. Margarets Bay

Scheibling (pers. comm. 2001) proposed St. Margarets Bay on the basis that macroalgae are highly productive in this inlet and a high volume of ecological information about the Bay's macrophyte population is available.

Chebucto Peninsula/Chebucto Head

Both Chapman (pers. comm. 2001) and Scheibling (pers. comm. 2001) proposed the Chebucto Peninsula, separating Halifax Harbour from St. Margarets Bay, as significant for a number of reasons. This area supports continuous intertidal rocky bottom suitable as seaweed habitat that extends to greater depths than in most areas along the coast. This deep rock habitat, in combination with clear water conditions allows for beds of *Ptilota*, *Odonthalia* and *Phyllophora* (red algae) at up to 25 m depth (Chapman pers. comm. 2001, Scheibling pers. comm. 2001).

Central Coast

Scheibling (pers. comm. 2001) proposed the coast between Halifax and Lockeport (in lower Shelburne County, SHACI Unit 2) as significant because it constitutes what is probably the most dynamic subtidal ecosystem in the world.

Threats and vulnerability

Scheibling (pers. comm. 2001) identified the primary threat to marine plant communities as invasive species, citing the green alga, *Codium fragile* spp. *tomentosoides* (Dead Man's Fingers), and colonial invertebrate, *Membranipora membranacea*, in particular. Researchers have discovered *Codium* in dense stands in Prospect and St. Margarets Bays, and *Membranipora* in frequent association with *Codium* stands (Davis and Browne 1996, Benthic Ecology Lab 2001). Chapman (pers. comm. 2001) indicated that coastal development threatens nearshore seaweed communities, citing municipal sewage outfalls and residential septic field runoff as important elements of this activity. Sewer and septic field runoffs contribute nutrient subsidies in such great quantities that filter feeders, such as mussels, out-compete algal communities. The organic sediments released by sewage can prevent spore settlement (Sharp pers. comm. 2005). Sewage outfalls are problematic around the Halifax area, where they are particularly plentiful. Effluent from point sources such as fish processing plants also harm marine plants (Sharp pers. comm. 2001).

Knowledge gaps

Knowledge of macroalgae in SHACI Units 4-6 is limited, coming predominantly from large-scale surveys conducted during the 1980s and a number of small, independent, local studies (see for example Mann 1972, Moore and Miller 1983, Moore et al. 1986, and Novaczek and McLachlan 1989). The information that we do have about seaweeds is concentrated on species of high commercial interest, and in areas of high commercial activity (e.g., southwest Nova Scotia). We know little about discrete areas of high seaweed biodiversity or species diversity in seaweed habitats. Scheibling (pers. comm. 2001) indicated that Nova Scotia's coast has been the subject of very little ecological research effort; habitat mapping is incomplete and out of date, interactions are not studied, and changes in those values are neither monitored nor tracked. We also do not know how invasive species are established locally, what vectors they used or their direction of propagation (Scheibling pers. comm. 2001).

The ecological impacts of marine plant harvesting are also poorly known, particularly because we do not understand its inter-relationships and degree of dependence with associated species such as periwinkles and smaller macroalgae. In addition, exposed seaweed beds are not well studied in Nova Scotia because it is difficult to work in high wave environments where they are found (Moore and Miller 1983).

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10 - Marine invertebrates

The coastal waters off Halifax Regional Municipality (HRM) host dozens of marine invertebrates found in a variety of habitat types. Invertebrates occupy the intertidal zone (littoral habitat) or subtidal zones such as the water column (pelagic habitat) and seafloor (benthic habitat). Types of benthic habitat are muddy, sandy, rocky, bedrock and mixed. Marine invertebrates found within SHACI Units 4-6 consist of several important commercial species and many others that are not commercially fished, little known and infrequently studied.

Littoral fauna

The intertidal or littoral zone is the area between the extreme high tide and extreme low tide levels in the sea (Davis and Browne 1996). Littoral invertebrates from three faunal regions (i.e. subarctic, boreal and temperate) are variously distributed along the Nova Scotia coast, with intermittent incursions of fauna from a fourth zone (i.e. warm temperate-tropical). Boreal fauna is commonly found on rocky exposed shores, and warm water temperate fauna are typically within more sheltered inner basins, such as Jeddore Harbour and Chezzetcook Inlet (Bousfield and Laubitz 1972). Bousfield and Laubitz (1972) surveyed littoral marine invertebrates along the Atlantic coast of Nova Scotia, employing 17 sample sites within each of SHACI Units 5 and 6 but none within Unit 4. They found 21 faunal region indictaors from warm temperate, winter-mild thermophile and cold-water sub-arctic species in embayments within HRM waters (Table 10-1), and noted that most warm-water molluscs appear in pockets west of Sheet Harbour.

Subtidal fauna

Information about the benthic community in subtidal areas of the HRM coast is limited. A study by Mitchell (2000) reported that very few benthic fauna assessments have been performed in this area, and presented a summary of results from surveys for caloric content and polychaete distribution in the late 1960s to early 1980s in St. Margarets Bay. Invertebrate phyla contributing to the total caloric content included annelids, echinoderms, arthropods and molluscs. Caloric content peaked when the bottom substrate was composed of a near 50/50 split between fine sand (diameter 0.037-0.25 mm) and silt with clay (diameter <0.037 mm). Miller et al. (1971) estimated the faunal biomass (kcal/m^2) of St. Margarets Bay, as follows: lobsters (1.7), brittle stars (2.0), seastars (4.0), periwinkles (12.0), mussels (13.6) and sea urchins (87.1).

While production of the polychaete *Pectinaria hyperborea* varied considerably within St. Margarets Bay, all sites exceeding 5 g/m^2 were within its deep (>60 m) and muddy areas (Peer 1970). A later study by Volkaert (1987) at shallower depth (46 m) and clay-silt substrate identified 67 polychaete species with densities ranging from <1 individuals/m^2 to >1000 individuals/m^2 (*Aricidea* sp. [juveniles] and *Cossura longocirrata* [juveniles]). Trophic groups represented in this faunal assemblage included filter feeders (10.4%), surface deposit feeders (23.9%), burrowers (25.4%), herbivores (7.5%), carnivores (31.3%) and unknown (1.5%). In addition, a 1980-1982 survey in Coyle Cove (within Blind Bay in SHACI Unit 4) identified 94 distinct taxonomic groupings belonging to one of five feeding types: carnivores, herbivores, omnivores, deposit feeders and suspension feeders (Moore et al. 1982).

No single survey describes the distribution of subtidal marine invertebrate species within SHACI Units 4-6. Their distribution can, however, be inferred from summary geographic occurrences reported by the Marine Invertebrate Diversity Initiative (MIDI) and other reports. The MIDI database is collated from a large selection of historical and current literature, published surveys and anecdotal reports. There are, however, several limitations associated with this data. The MIDI database is not exhaustive, and remains a work in progress. It presents data from existing published and unpublished sources and adds new information as it becomes available. Information is presently available for 1200 species, although as many as 3500 species are thought to inhabit the total domain of the Initiative (including the Bay of Fundy, Gulf of Maine and Scotian Shelf) (MIDI 2003). Examination of the MIDI database indicates the presence of at least 200 species or species groups of marine invertebrates in HRM waters (Table 10-2).

Table 10-1: Faunal region indicator invertebrate species by class, SHACI Unit and site name or number (compiled from Bousfield and Laubitz 1972)

Classes	Species name	Unit 5	Unit 6
Warm water fauna			
ans	*Corophium insidosum*	All sites	All sites
	Bittium alternatum	Ostrea Lake, Oyster Pond above bridge	Jewer Cove near Mitchell Bay, Malagash Cove
	Tellina agilis		Jewer Cove; Moosehead, White Island Bay; Sober Island
	Caprella penantis	Chezzetcook Inlet	Psyche Cove, south end
	Leptochelia rapax	Ostrea Lake	Malagash Cove
	Mysis stenolepis	Ostrea Lake; Chezzetcook Inlet	E. Quoddy Pond; Jewer Cove, Sober Island
es	*Mitrella lunatia*	Oyster Pond above bridge	
	Nassarius obsoletus	Oyster Pond above bridge, Oyster Pond (head Jeddore Harbour)	Malagash Cove; Mushaboom Harbour;
	Crassostrea virginica	Upper Oyster Pond, Oyster Pond above bridge	
	Volsella demissa	Upper Oyster Pond, Ostrea Lake, Oyster Pond above bridge	
	Petricola pholadiformis	Oyster Pond above bridge	Jewer Cove near Mitchell Bay
[illegible] Mild Thermophile Fauna			
	Amphiporeia virginiana	All sites	All sites
	Marino gammarus finmarchicus	All sites	All sites
	Bathyporeia quoddyensis	Martinique Beach, Clam Harbour Beach	Psyche Cove
	Chirodothea caeca	All sites	All sites
	Orchestia grillis	All sites	All Sites
Cold Water and Sub-Arctic Fauna			
ans	*Mysis gaspensis*		Marie Joseph Beach; Baker Cove
	Balanus balanus		Psyche Cove
	Mancocuma stellifera	Meisner Head	Psyche Cove
	Skenea planorbis		Jewer Cove; Tangier& Popes Harbours
	Margarites helicinus		Psyche Cove, Popes Harbour
es	*Mesodesma arctatum*	Meisner Head, Clam Harbour Beach	Marie Joseph Beach, Psyche Cove
	Volsella modiolus	Beach opposite Conrod Island	Psyche Cove

'The species distributions presented above were interpreted from a combination of text, table and graphic information. Other interpretations are possible.

Table 10-2: Invertebrate species sampled in select inlets of SHACI Units 4-6 (based on data from MIDI 2003 and Moore et al. 1982)

Common name /synonym	Species Name	Cranberry Cove, St. Margarets Bay*	Peggy's Cove, St. Margarets Bay*	Martins Point, St. Margares Bay*	St. Margarets Bay*	Dover Harbour*	Halifax Harbour*	Northwest Arm, Halifax Harbour*	Chezzetcook Inlet*	Petpeswick Inlet*	Sheet Harbour*	Coyle Cove**
Nemerteans												X
Marine worms / Annelida												
Oligochaetes												X
Polychaetes												X
	Asabellides siberica					X						
Lugworm	*Arenicola marina*									X		
	Pectinaria gouldi									X		
	Pectinaria granulata				X					X		
	Scoloplos acutus				X					X		
	Scoloplos armiger											
	Scoloplos robustus				X					X		
	Spiophanes bombyx									X		
Hard tube worm	*Spirorbis borealis*		X		X					X		
	Cistenides hyperborea				X		X					
	Nothrya conchylega				X		X					
	Arcteobia anticostiensis				X							
	Axiothella catenata											
	Bylgides sarci				X							
	Chaetozone setosa				X							
	Chone duneri				X							
	Dispio uncinata				X							
	Gattyana cirrosa				X							
	Gyptis vittata				X							
	Hartmania moorei				X							
	Laonice cirrata				X							
	Maldane sarsi											
	Neanthes succinea		X		X							
	Nothrya conchylega				X		X					
	Polynoe gracilis				X							

Common name /synonyms	Species Name	Cranberry Cove, St. Margarets Bay*	Peggy's Cove, St. Margarets Bay*	Martins Point, St. Margarets Bay*	St. Margarets Bay*	Dover Harbour*	Halifax Harbour*	Northwest Arm, Halifax Harbour*	Chezzetcook Inlet*	Petpeswick Inlet*	Sheet Harbour*	Coyle Cove**
	Polyphysia crassa				X							
	Praxillella gracilis											
	Praxillura ornata				X							
	Sarsonuphis quadrocuspis											
	Sternaspis scutata				X							
Fringed worm	*Tharyx acutus*											
Paddle worms	*Eteone flava*				X				X			
	Anaitides groenlandica									X		
	Anaitides maculata		X							X		
	Anaitides mucosa				X					X		
	Eteone longa				X					X		
	Eulalia viridis							X		X		
Clam worms	*Nereis diversicolor*								X			
	Neanthes virens									X		
	Nephtys incisa						X	X		X		
	Nereis pelagica							X		X		
	Nereis acuminata									X		
	Nephtys ciliata				X							
Fan worms	*Potamilla neglecta*											
	Fabricia sabella								X			
Mud worm	*Polydora ligni*								X	X		
	Spio filicornis								X	X		
	Streblospio benedicti								X			
	Pygospio elegans									X		
	Prinospio malmgreni				X							
	Spio setosa									X		
Orbiniid worm	*Scoloplos fragilis*								X			
	Aricidea quadrilobata				X							
	Orbinia ornata									X		
Paraonid worm	*Aricidea suecica*				X							
	Paraonis fulgens									X		

Common name /synonyms	Species Name	Cranberry Cove, St. Margarets Bay*	Peggy's Cove, St. Margarets Bay*	Martins Point, St. Margarets Bay*	St. Margarets Bay*	Dover Harbour*	Halifax Harbour*	Northwest Arm, Halifax Harbour*	Chezzetcook Inlet*	Petpeswick Inlet*	Sheet Harbour*	Coyle Cove**
Flabelligerid worm	*Pherusa plumosa*				X		X			X		
	Brada villosa				X							
Bamboo worm	*Praxillella praetermissa*				X					X		
	Nicomache lumbricalis				X		X					
	Clymenella torquata									X		
Terebellid worm	*Amphitrite figulus*									X		
	Amphitrite ornata				X							
Blood worm	*Glycera capitata*				X							
Chevron worm	*Goniada brunnea*				X							
	Goniada maculata				X							
Lumbrinerid thread worm	*Lumbrineris fragilis*				X					X		
	Ninoe nigripes				X							
Scaled worms	*Harmothoe extenuata*						X			X		
	Harmothoe imbricata		X		X		X	X		X		
	Lepidonotus squamatus		X							X		
	Pholoe minuta				X							
Capitellid thread worm	*Capitella capitata*				X							
	Notomastus latericeus									X		
Red-lined worm	*Nephtys bucera*									X		
	Nephtys incisa									X		
Arthropods	*Idotea phosphorea*	X	X		X				X	X		
	Leptochelia rapax									X		
Sharp-tailed cumacean	*Oxyurostylis smithi*									X		X
Euphausiids												X
	Aeginina longicornis								X			
	Chirodotea tuftsii								X			
	Mancocuma stellifera								X			
	Oniscus asellus								X			
	Porcellio scaber								X			
	Tmetonyx nobilis								X			
	Evadne nordmanni	X	X		X							

Common name /synonyms	Species Name	Cranberry Cove, St. Margarets Bay*	Peggy's Cove, St. Margarets Bay*	Martins Point, St. Margarets Bay*	St. Margarets Bay*	Dover Harbour*	Halifax Harbour*	Northwest Arm, Halifax Harbour*	Chezzetcook Inlet*	Petpeswick Inlet*	Sheet Harbour*	Coyle Cove**
	Podon polyphemoides	X			X							
	Casco bigelowi	X	X									
	Eurytemora affinis	X	X									
	Marinogammarus finmarchius	X	X									
	Oithona similis	X	X									
	Pontogeneia inermis	X										
	Temora longicornis	X	X									
	Temora stylifera	X	X									
Isopods												X
	Jaera marina	X	X		X				X	X		
	Chirodotea coeca									X		
	Idotea balthica		X						X			
Rock crab	*Cancer irroratus*								X		X	
Toad crab	*Hyas coarctatus*				X				X			
Toad crab	*Hyas araneus*				X							
Acadian hermit crab	*Pagurus acadianus*								X			
Hairy hermit crab	*Pagurus arctuatus*		X						X			
Blue crab	*Callinectes sapidus*				X							
Green crab	*Carcinus maenus*		X									
Barnacles												X
Pelagic goose barnacle	*Lepas fascicularis*		X									
Northern rock barnacle	*Semibalanus balanoides*		X									
Amphipods												X
	Corophium tuberculatum									X		
	Gammarus oceanicus	X								X		
	Ampithoe rubricata	X	X									

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Scud	*Gamarus mucronatus*									X		
	Gammarus lawrencianus								X			
	Gammarus tigrinus	X	X									
Mud shrimp	*Corophium volutator*	X	X		X							X
Sevenspine bay shrimp	*Crangon septemspinosa*							X	X			
Caridean shrimp	*Lebbeus groenlandicus*		X									
Common American prawn	*Palaemonetes vulgaris*		X									
Aesop shrimp	*Pandalus montagui*				X							
Gribble	*Lignoria lignorum*								X			
Beach flea	*Talorchestia longicornus*								X			
Beach flea	*Talorchestia megalopthorma*								X			
Arctic argid	*Argis dentata*				X							
American lobster	*Homarus americanus*		X		X							
Mollusca												X
	Catriona aurantia								X			
	Lora bicarinata								X			
	Montacuta bidentata								X			
	Hiatella arctica		X									
Double-sutured odostome	*Boonea bisuturalis*								X	X		
Tripartite odostome	*Odostomia trifida*								X			
Gem Shell	*Gemma gemma*								X	X		
Swamp hydrobia	*Hydrobia truncata*								X	X		
Pyram	*Pyramidella fusca*								X	X		
Alternate bittium	*Bittium alternatum*								X			
Solitary glassy bubble	*Haminoea solitaria*								X			
Channeled barrel bubble	*Retusa canaliculata*								X			

Common name /synonyms	Species Name	Cranberry Cove, St. Margarets Bay*	Peggy's Cove, St. Margarets Bay*	Martins Point, St. Margarets Bay*	St. Margarets Bay*	Dover Harbour*	Halifax Harbour*	Northwest Arm, Halifax Harbour*	Chezzetcook Inlet*	Petpeswick Inlet*	Sheet Harbour*	Coyle Cove**
Arctic barrel bubble	*Retusa obtusa*								X			
Giant canoe bubble	*Scaphander punctostriatus*				X							
Shelled sea butterfly	*Limacina retroversa*								X			
Glassy lyonsia	*Lyonsia hyalina*								X			
Pointed cingula	*Onoba aculeus*								X			
False angel wing	*Petricola pholadiformis*								X			
Ribbed pod	*Siliqua costata*								X			
Flat-coiled skeneopsis	*Skeneopsis planorbis*								X			
Dwarf tellin	*Tellina agilis*								X			
Common shipworm	*Tereda navalis*								X			
Interrupted turbinille	*Turbonilla interrupta*								X			
Short yoldia	*Yoldia sapotilla*				X							
Broad yoldia	*Yoldia thraciaeformis*				X							
Smooth helical top shell	*Margarites helicinus*				X							
Smooth jingle shell	*Anomia simplex*		X									
Island cockle	*Clinocardium ciliatum*				X							
Northern rosy top shell	*Margarites costalis*								X			
Common Atlantic chinck shell	*Lacuna vincta*								X			
Flat slipper shell	*Crepidula plana*								X			
Common periwinkle	*Littorina littorea*		X		X				X	X	X	
Rough periwinkle	*Littorina saxatilis*									X		
Smooth periwinkle	*Littorina obtusata*		X									
Baltic macoma	*Macoma balthica*								X	X		
Soft-shelled clam	*Mya arenaria*								X	X		
Atlantic jack-knife	*Ensis directus*								X	X		

Common name /synonyms	Species Name	Cranberry Cove, St. Margarets Bay*	Peggy's Cove, St. Margarets Bay*	Martins Point, St. Margarets Bay*	St. Margarets Bay*	Dover Harbour*	Halifax Harbour*	Northwest Arm, Halifax Harbour*	Chezzetcook Inlet*	Petpeswick Inlet*	Sheet Harbour*	Coyle Cove**
Arctic wedge clam	*Mesodesma arctatum*								X			
Little surfclam	*Mulinia lateralis*								X			
Surf clam	*Spisula solidissima*								X			
Quahog	*Mercenaria mercenaria*										X	
False quahog	*Pittar morhuanus*								X			
White chiton	*Ischnochiton albus*		X									
White chiton	*Stenosemus albus*								X			
Northern red chiton	*Tonicella rubra*								X			
Glandular bean mussel	*Crenella glandula*				X							
Horse mussel	*Modiolus modiolus*				X				X			
Blue mussel	*Mytilus edulis*									X		
Smooth discord mussel	*Musculus discors*								X			
	Mytilus trossulus	X	X									
Plant limpet	*Tectura testudinalis*	X	X									
Slipper limpet	*Crepidula fornicata*								X			
Atlantic dogwinkle	*Nucella lapillus*		X		X				X			
New England dogwhelk	*Nassarius trivittatus*								X			
Arctic moonsnail	*Cryptonatica affinis*			X								
Bidentate ear snail	*Melampus bidentalus*								X			
Arctic rock borer	*Hiatella arctica*								X			
Spotted moonshell	*Euspira triseriata*								X			
Common moon snail	*Euspira heros*								X			
Clubbed sea slug	*Doto onusta*								X			
Bushy-backed nudibranch	*Dendronotus frondosus*								X			
Waved whelk	*Buccinum undatum*								X			

Common name /synonyms	Species Name	Cranberry Cove, St. Margarets Bay*	Peggy's Cove, St. Margarets Bay*	Martins Point, St. Margarets Bay*	St. Margarets Bay*	Dover Harbour*	Halifax Harbour*	Northwest Arm, Halifax Harbour*	Chezzetcook Inlet*	Petpeswick Inlet*	Sheet Harbour*	Coyle Cove**
Sponges												X
	Cliona celata								X			
	Halichondria panicea								X			
Cnidarians												X
Northern red anemone	*Urticina felina*		X						X			
Plumose anemone	*Metridium senile*	X	X									
Garland hydroid	*Dynamena pumila*		X									
Sea cauliflower	*Capnella florida*				X			X				
Flatworms												X
	Foviella affinis								X			
	Notoplana atomata								X			
	Procerodes ulvae								X			
Ribbon Worms	*Cerebratulus fusca*								X			
	Micrura leidyi								X			
	Oerstedia dorsalis								X			
Echinoderms												X
Green sea urchin	*Strongylocentrotus droebachiensis*		X						X			
Boreal asterias	*Asterias vulgaris*		X		X							
Mud star	*Ctenodiscus crispatus*				X							
Orange-footed cucumber	*Cucumaria frondosa*				X							
	Molpadia oolitica				X							
Blood star	*Henricia sanguinolenta*		X									
Daisy brittle star	*Ophiopholis aculeata*		X									

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Bryozoa												X
Lazy crust bryozoan	*Membranipora membranacea*		X									
Urochordates – Sea vase	*Ciona intestinalis*			X								
Peanut Worms - Hermit sipunculid	*Phascolion strombi*				X							

Commercial species

Halifax Regional Municipality coastal waters are productive areas for several marine invertebrates, many of which are fished commercially. The lobster and softshell clam fisheries are economically important in some Eastern Shore and Western Shore coastal communities. Rock crab is a recently developed fishery east of Halifax, and scallops, mussels and periwinkle have been harvested periodically on a small scale for several years. Green sea urchins are of significant commercial interest, but their harvestable quantities fluctuate dramatically due to disease-induced mortality. Shrimp, snow crab, toad crab and jonah crab continue to be of commercial interest although their distribution throughout SHACI Units 4-6 is sparse, unknown and/or patchy. Sandworms are also gathered locally from soft bottom areas for the bait fishery (HCESCRMP 1996, HRMWRCRMP 1996, Weber pers. comm. 2003).

The times of key life history events, including moulting, spawning, and planktonic staging, vary from species to species. Some of these data are known about individual species, but no comprehensive summary exists for SHACI Units 4-6. The summary provided for that area suggested that there are planktonic stage invertebrates in the water column for most of the year, between mid-February and the end of November. Information collected about invertebrates inhabiting SHACI Units 4-6 has not indicated any significant differences in the timing of life history events between the Eastern Shore and Sydney Bight. Thus, one may cautiously assume that planktonic invertebrate larvae also inhabit HRM waters throughout most of the year.

Despite the economic and, in some cases, ecological importance of invertebrates in SHACI Units 4-6, there are significant gaps in our knowledge of these species. General distribution data is available for some commercial species and fewer non-commercial species, however it is typically low-resolution and more often available for areas away from the shore. Miller (pers. comm. 2003) summarized known information about lobsters along the Eastern Shore, and Biron et al. (2002) similarly summarized information about snow crabs. These summaries among many others are included in the following sections.

American lobster (Homarus americanus)

American lobster is the marine species most frequently associated with Nova Scotia. Lobsters are widespread and common along the Atlantic coast. East and west of Halifax, they are usually found inshore, at depths less than 40 m (Tremblay pers. comm. 2003a). With the exception of soft bottom areas, the vast majority of the HRM coast could be considered lobster habitat (Miller pers. comm. 2003). This is confirmed by traditional ecological knowledge, which identifies lobster bottom all along SHACI Units 4-6 coastal areas (Figures 10-1a to 10-1h) (HCESCRMP 1996, HRMWWRCRMP 1996, GCCRMP 1994, LCCRMP 1996). Lobster stocks in SHACI Units 4-6, although supporting one of the areas' largest fisheries, are thought to be considerably smaller than those of Sydney Bight and southwest Nova Scotia based on respective landing statistics. Despite the smaller population size, more large egg-bearing females are found on the Eastern Shore than elsewhere along the Atlantic coast (Miller pers. comm. 2003). Miller (1997) showed that egg-bearing female American lobsters are three times more abundant in St. Margarets Bay and inlets north to Halifax Harbour compared to southwest Nova Scotia, despite an opposite trend in the abundance of lobster larvae and fishery recruits. The cause of this discrepancy is unknown, although there are two principle hypotheses: low local larval survival and larval retention in HRM coastal waters. Larval survival may be higher in both the Sydney Bight and southwest shore waters due to warmer water and nutrient rich currents. Larval retention may be lower in SHACI Units 4-6 due to unfavourable currents when lobster larvae are planktonic.

Lobsters migrate along an inshore-offshore axis on a seasonal basis, moving between shallow and deep water. Year round monitoring studies in Shad Bay indicated that lobsters leave the heads of bays by mid-October for waters up to approximately 40 m deep, 7.2 – 10.5 km offshore where they overwinter. Following this period they return to water less than 33 m deep for the summer. Although the time of their return to their place of origin is less well documented, Miller (pers. comm. 2003) says the rule of thumb is May or June, a trend that is assumed to apply along the entire coast of Nova Scotia. These migrations, though varying in distance by individual, are typically less than 10 km along the eastern Nova Scotia shore (Campbell 1989, Miller et al. 1989). Reasons for these migrations are unknown.

The population size of lobsters within SHACI Units 4-6 is not well known, as DFO does not collect this kind of information at the scale of SHACI's study area. Fishery landings data are the best proxy indicator for this value. Lobster landings in eastern Nova Scotia (ENS) peaked in 1991/1992 and have declined since then; the decline has levelled off in some areas and not in others. The present lobster population size may approximate the long-term average over these areas (Tremblay pers. comm. 2003a).

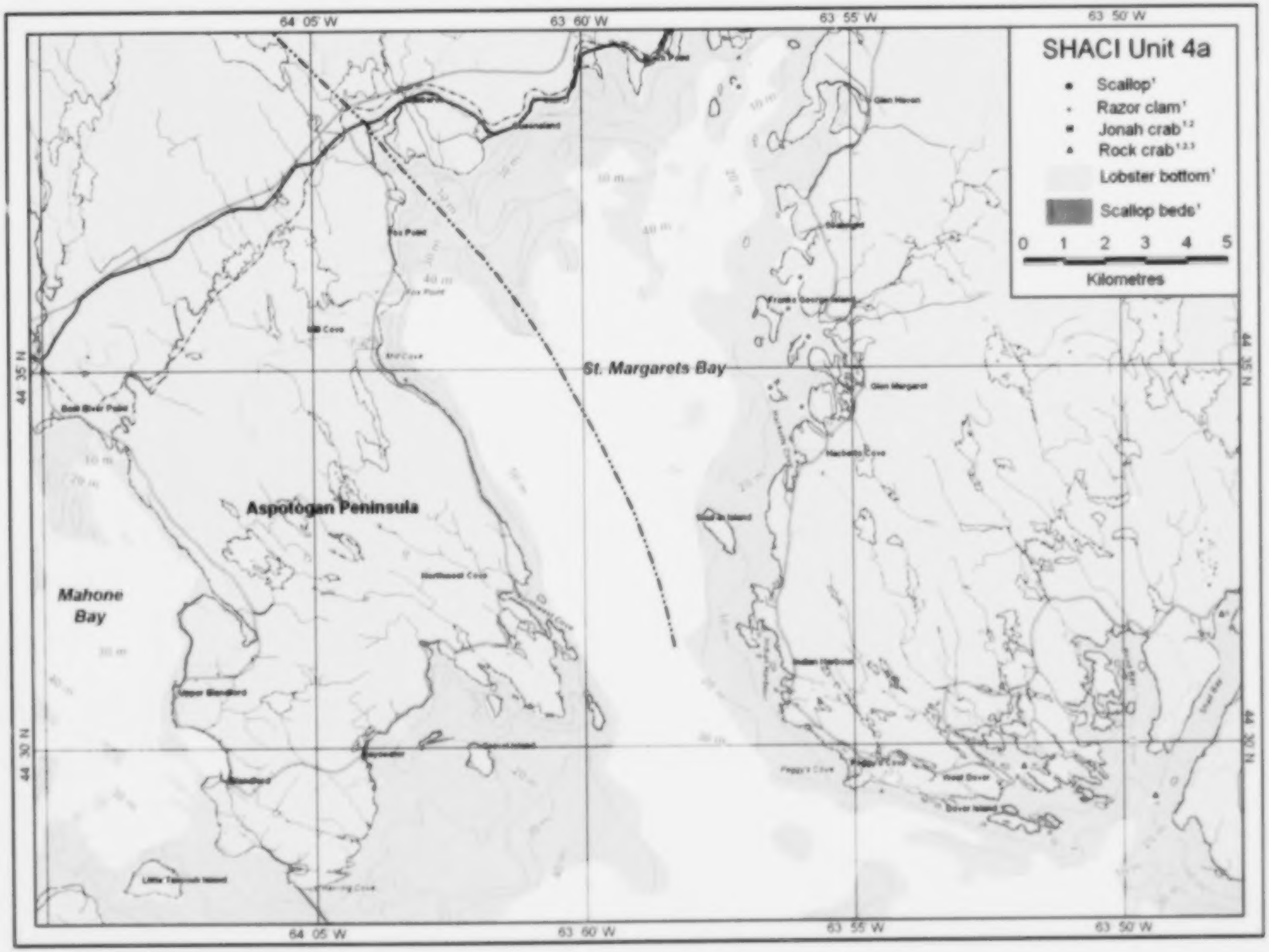

Figure 10-1a: Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 4a (based on data from HRMWRCRMP 1996, LCCRMP 1996, MFDVDC 2003 and Tremblay 2003b). Basemap layers (NRCan).

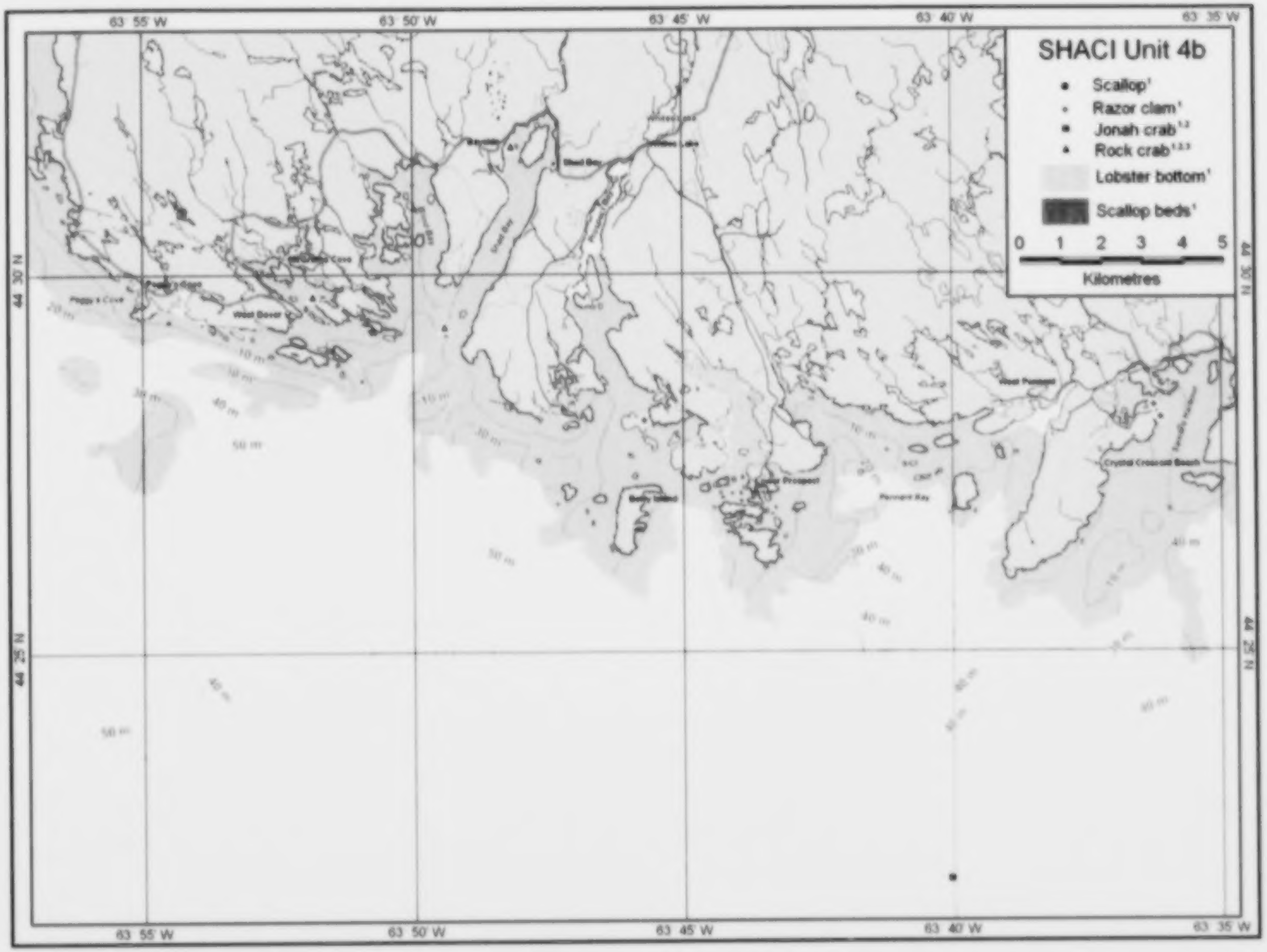

Figure 10-1b: Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 4b (based on data from HRMWRCRMP 1996, MFDVDC 2003 and Tremblay 2003b). Basemap layers (NRCan).

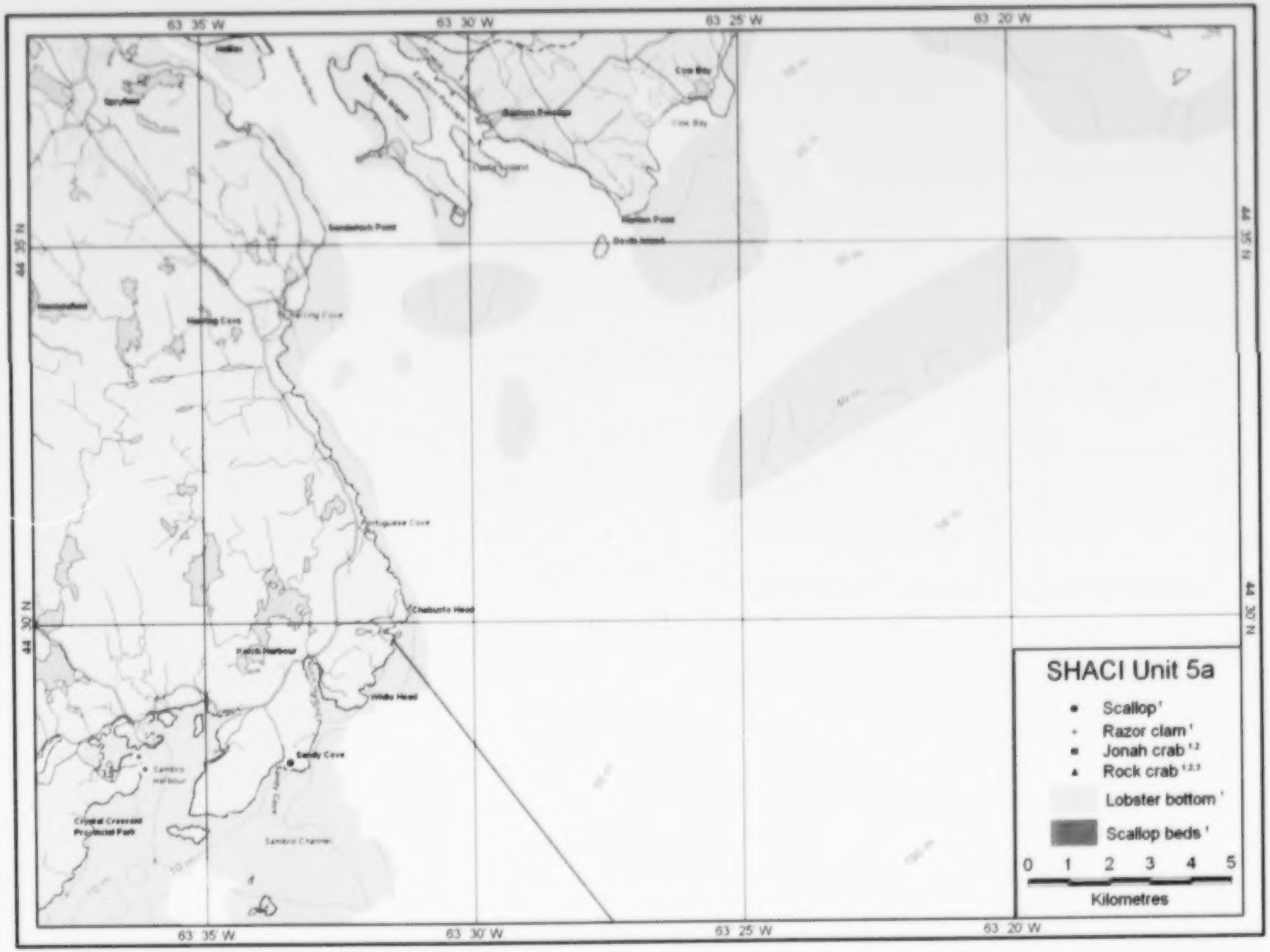

Figure 10-1c: Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 5a (based on data from HCESCRMP 1996, HRMWRCRMP 1996, MFDVDC 2003 and Tremblay 2003b). Basemap layers (NRCan).

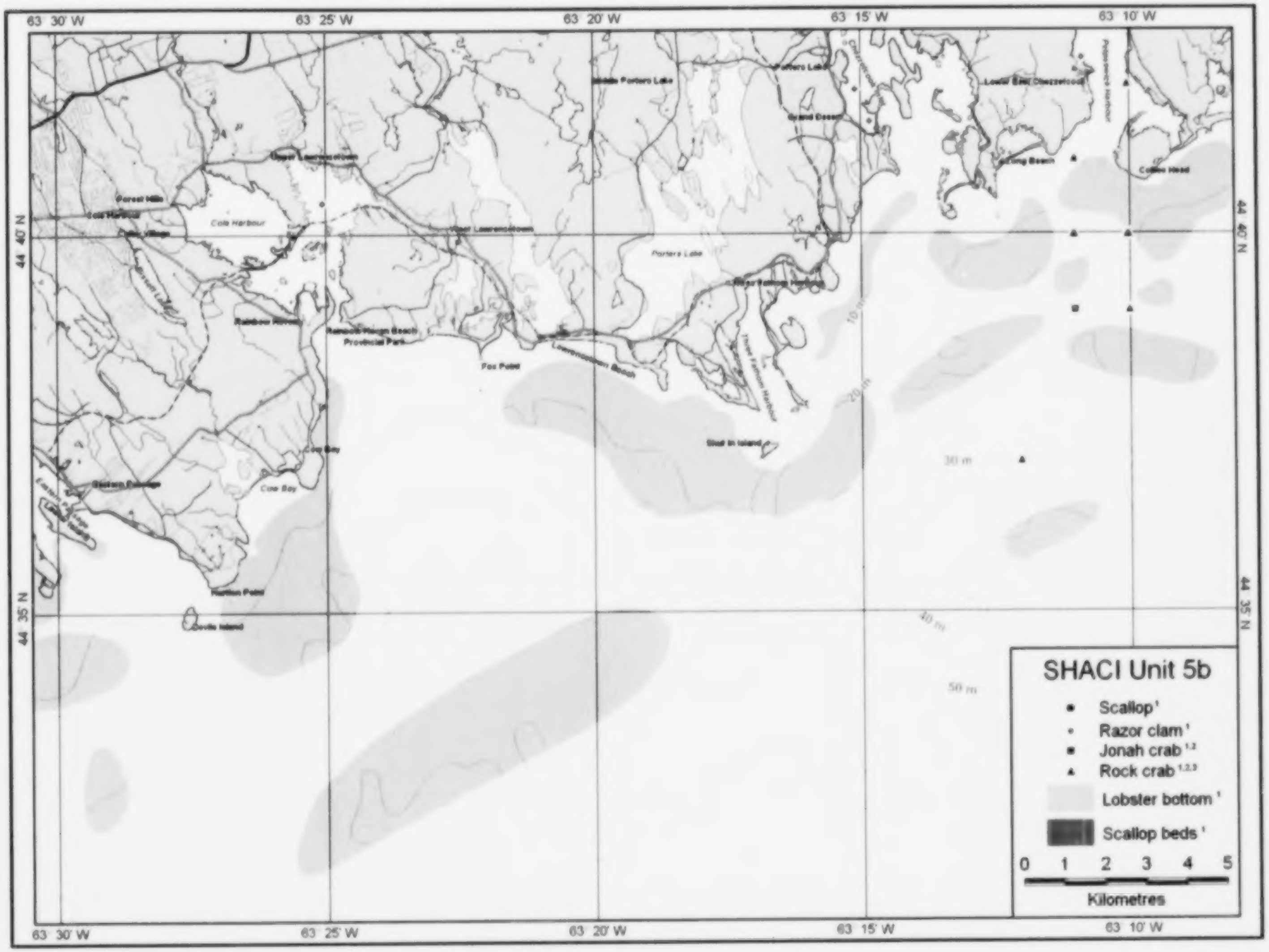

Figure 10-1d: Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 5b (based on data from HCESCRMP 1996, MFDVDC 2003 and Tremblay 2003b). Basemap layers (NRCan).

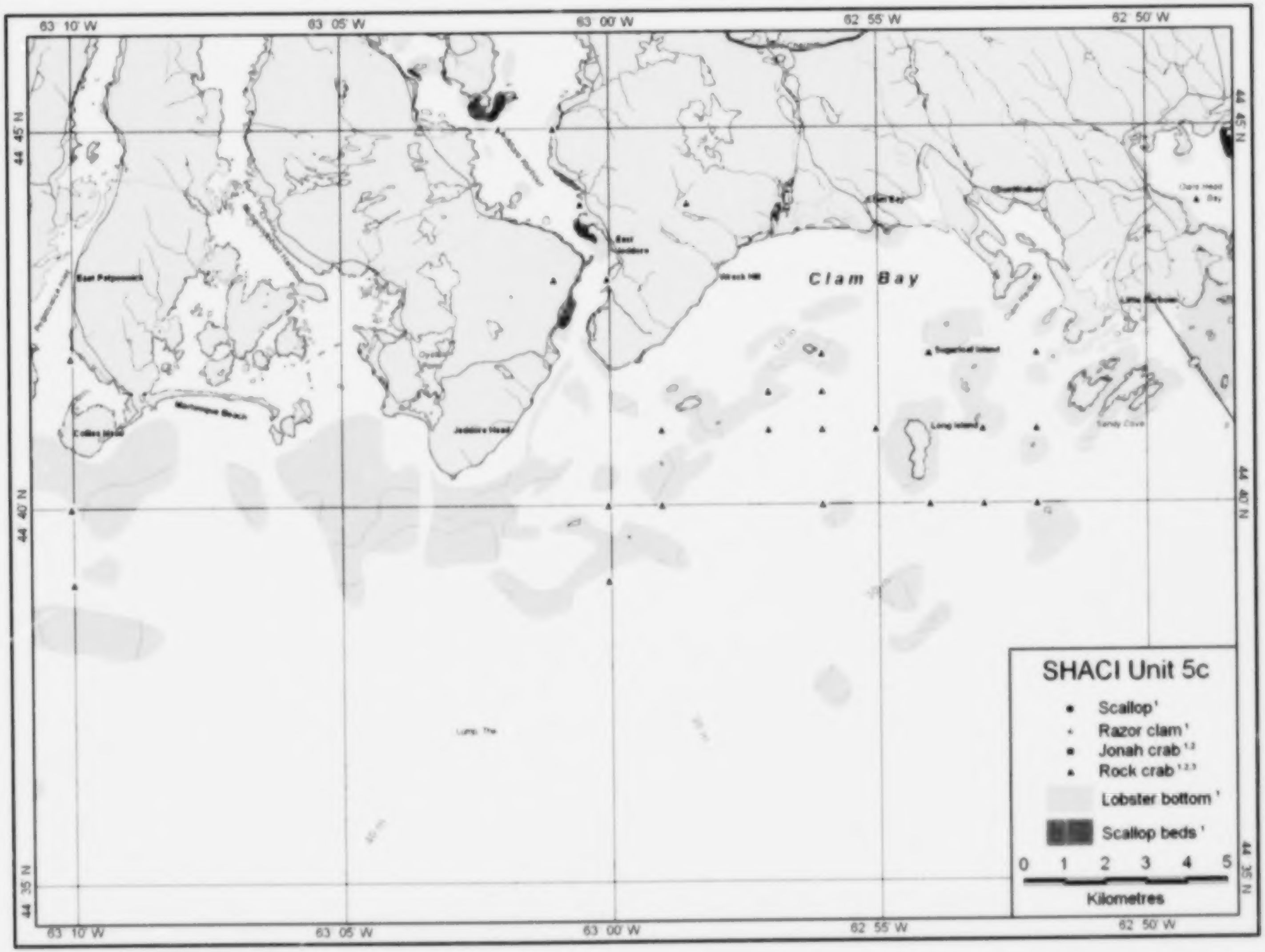

Figure 10-1e: Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 5c (based on data from HCESCRMP 1996, MFDVDC 2003 and Tremblay 2003b). Basemap layers (NRCan).

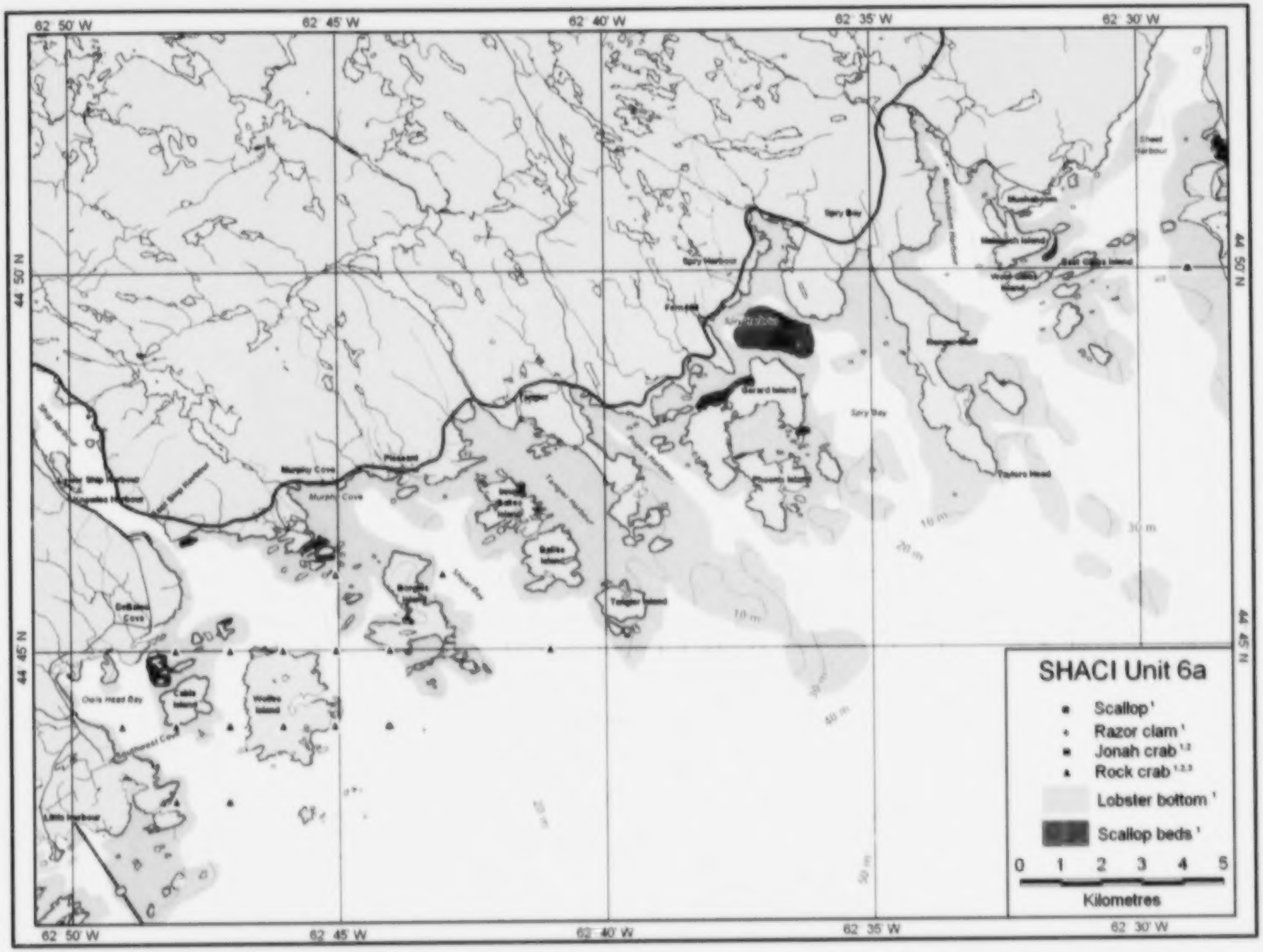

Figure 10-1f: Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 6a (based on data from HCESCRMP 1996, MFDVDC 2003 and Tremblay 2003b). Basemap layers (NRCan).

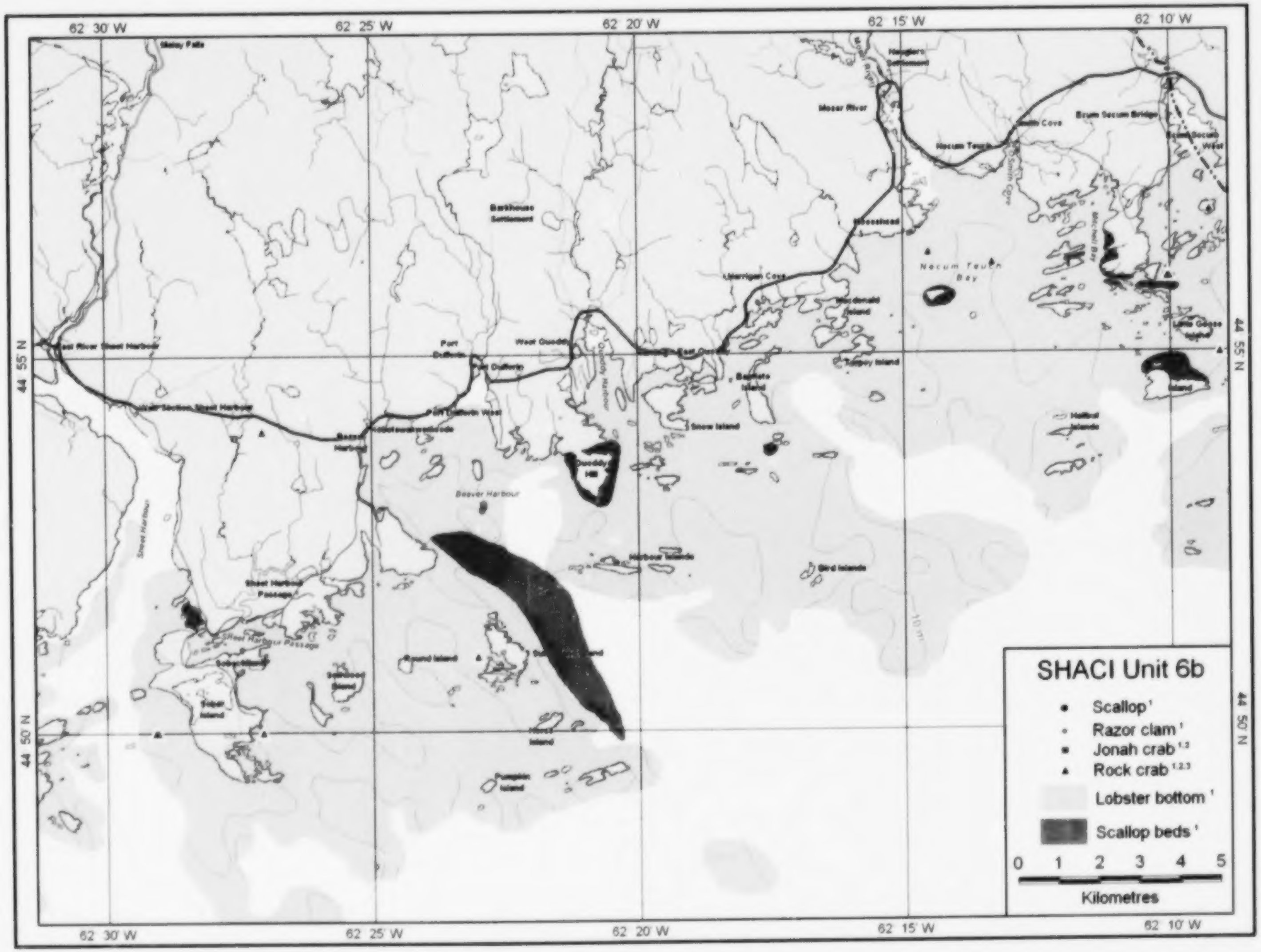

Figure 10-1g: Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 6b (based on data from HCESCRMP 1996, MFDVDC 2003 and Tremblay 2003b). Basemap layers (NRCan).

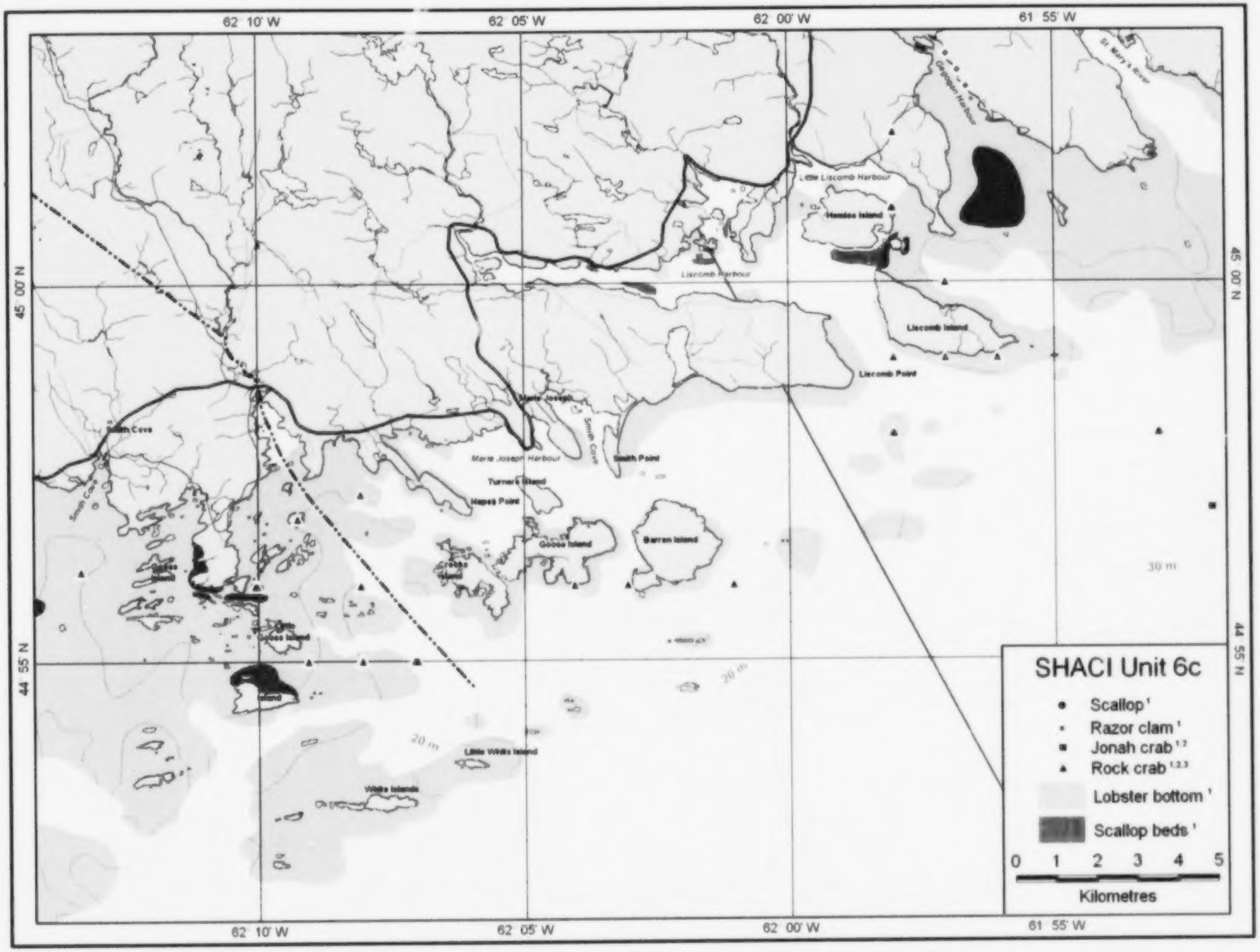

Figure 10-1h: Locations of scallops, razor clams, Jonah crabs, rock crabs, lobster bottom and scallop beds in SHACI Unit 6c (based on data from GCCRMP 1994, HCESCRMP 1996, MFDVDC 2003 and Tremblay 2003b). Basemap layers (NRCan).

Snow crab (Chionectes opilio)

Snow crab distribution within SHACI Units 4-6 is not well documented but can be inferred from areas targeted by the increasingly inshore fishery. Accordingly, the population is currently distributed along the 12 nm contour and scattered areas further inshore, roughly located between Ship Harbour and Necum Teuch (Biron et al. 2002). The distance between local fishing grounds is large compared to areas further east, and the amount of fishing effort is similarly low. Snow crabs off Nova Scotia's Atlantic coast are commonly grouped according to biological units: ENS and southwestern Nova Scotia (SWNS). The ENS is further divided into northern and southern regions. The southern region spans between Halifax Harbour in the south and approximately Scatarie Island in the north. Snow crabs occupying SHACI Units 4-6 are at the southern margin of the southern ENS Region (Biron et al. 2002).

Commercial-sized (>95 mm carapace width) and adolescent (≥56 mm and ≥76 mm) males showed a patchy distribution in most sub-areas from 1997 to 2001. In 2001, adult males were found at densities exceeding 2500 crabs/km^2 in a small concentrated area within SHACI Unit 6. Adolescent males were found at relatively low densities (between 3000 and 6000 crabs/km^2) off Necum Teuch. Distributions of snow crab vary by sex and size class, and little information is currently known about the distribution of females of any age class and other male size classes (Biron et al. 2002, Biron et al. 2003).

Although DFO research trawl surveys occur within parts of HRM coastal waters, no stations are shallower than ~90 m due to technical restrictions (Biron pers. comm. 2003). In addition, all surveying corresponds to the scale of management units (Crab Fishing Areas [CFAs]). Biron et al. (2002) indicate that CFAs 23 and 24 do not accurately reflect the biological distribution; scientists publish biomass estimates and survey results based only on southern and northern ENS units. Similarly, fishery catch analysis is not performed at the scale of SHACI units (Biron pers. comm. 2003). The abundance of mature females and pre-recruits has been decreasing since 1997-98 at a higher magnitude than observed in other areas showing the same trend, such as the southern Gulf and western Cape Breton (Biron et al. 2002).

Seasonal movements between shallow and deeper areas may occur, but their magnitudes have not been quantified in ENS to date. Biron et al. (2002) indicate a typical displacement of 15 km between tagging and recapture sites. Snow crabs typically inhabit bottom depths of 20-400 m. During DFO's 2002 trawl survey, over 50% of crabs caught in the Lahave Bank area (just beyond the outer boundary of SHACI Unit 4) were at 100-120 m depth, and most of the remainder were deeper still, to 200 m (Drinkwater et al. 2003).

The abundance, distribution, and habits of crabs younger than 'juvenile' are not available, for this area or any others, because commercial gear catches them infrequently and scientific surveys report biased data due to imperfect catchability (Biron pers. comm. 2003). Tremblay (pers. comm. 2003a) reports that after hatching, snow crab persist as larvae for 2-3 months, and the magnitude and direction of their dispersion is not well understood. A better understanding depends on more sophisticated ocean circulation modelling and knowledge of vertical migrations within the water column. Biron (pers. comm. 2003) likewise indicates that larval settling patterns and production have not yet been studied along ENS coast. Locations of important spawning or juvenile areas are similarly unknown within SHACI Units 4-6, although their existence is possible.

Rock crab (Cancer irroratus)

Rock crabs are among the most commonly seen crabs in Nova Scotia's inshore areas (Tremblay pers. comm. 2003a). Their specific distribution within inlets and the nearshore environment considered in SHACI is not well known, as DFO does not survey explicitly for this species and fishery data are limited because directed fisheries are not intense in this area (Tremblay pers. comm. 2003a, DFO 2000a). Rock crabs occur at Chezzetcook Inlet and Sheet Harbour (MIDI 2003), as well as several other locations east of Halifax as indicated by logbook positions from the directed fishery (Figures 10-1a to 10-1h) (DFO 2000a, MFDVDC 2003, Tremblay 2003b). Although the locations of stock boundaries are unknown at this time, it has been proposed that inshore populations may be distinct from the offshore population (DFO 2000a).

Generally, rock crabs prefer sand and soft mud bottoms but they also occur in lower abundance on hard bottoms (Tremblay pers. comm. 2003a). Rock crabs are predominantly subtidal; they are found commonly shallower than 20 m, but may also occur at depths approaching 750 m (Pohle 1990) and within the intertidal margin (Tremblay pers. comm. 2003a).

There is a wealth of life history information for this species (e.g., Bigford 1979), although there are no studies for SHACI Units 4-6. The population size within this area is unknown, but scientists believe there may be areas of local stock depletions where the fishery takes place. It is hoped that improvements in the information on the rock crab resource will result from planned changes proposed for lobster fishery logbooks (reporting of rock crab caught as bycatch and used as bait) (DFO 2000a, Kenchington 2000, Tremblay pers. comm. 2003a).

Jonah crab (Cancer borealis)

Jonah crabs have been captured in traps near Petpeswick Inlet, Musquodoboit Harbour, and the 100 m isobath between Halifax Harbour and St. Margarets Bay (Figures 10-1a-to 10-1h) (MFDVDC 2003). They are typically more plentiful south of Halifax, where fishery data shows them clustered in much higher abundance beyond the 12 nm limit southeast of SHACI Units 3 and 4 (MFDVDC 2003). Along the South Shore, Jonahs may be found by divers at depths shallower than 10 m, but their distribution becomes patchier and abundance drops eastward along the shore; very few are found in SHACI Unit 6 and areas further east (Tremblay pers. comm. 2003a).

Jonah crabs are usually found deeper than rock crabs and in higher-temperature waters. Despite the fact that this crab supports a commercial fishery, very little is known of this species, and its population boundaries are also unknown (DFO 2000b, Kenchington 2000).

Sea scallop (Placopecten magellanicus)

Scallops are most abundant in tidally well mixed areas with gravel or other hard bottom (Tremblay et al. 2001). They are typically distributed between 35 and 120 m depth, and may migrate between silty shallow areas in the summer and deeper gravel bottoms in the winter, although this is unconfirmed (Kenchington et al. 1991, Smith pers. comm. 2003). Tagging studies put the distance of these migrations at 10-20 m, but anecdotal information from fishermen on Georges Bank suggests that scallops may move several hundreds of metres (Smith pers. comm. 2003). Spawning usually occurs between August and the end of September, possibly triggered by temperature. An additional spawning period may occur during spring in inshore populations (DFO 2001, Smith pers. comm. 2003). Spawning beds are thought to be persistent, however it is not known whether they are maintained through the settling of larvae from the same or other scallop beds (Smith pers. comm. 2003). Larvae are thought to be planktonic for four to six weeks following spawning events (Tremblay et al. 2001).

Scallop beds were previously fished regularly between Shelburne and Canso, although many of these beds, particularly the small ones, have been fished out (Smith pers. comm. 2003). A mid-1980s DFO scallop research study confirmed active beds in Sheet Harbour, Liscomb Harbour, Necum Teuch Harbour, Mushaboom Harbour and Bay of Islands (Kenchington et al. 1991). Traditional ecological knowledge indicates the presence of scallop beds in several discrete areas (Figures 10-1a-to 10-1h) (GCCRMP 1994, HCESCRMP 1996, HRMWRCRMP 1996, LCCRMP 1996).

Northern shrimp (Pandulus borealis)

Northern shrimp inhabit cold waters (<6ºC) with muddy bottoms high in organic content. Populations of this species are frequently intermixed with the smaller striped shrimp, *P. montagui*, which seem to prefer slightly harder bottom and shallower water, and tolerate lower salinity water. On the eastern Scotian Shelf, *P. borealis* typically concentrate in deep "holes" including Canso, Whitehead, Misaine and Louisburg, and concentrations have recently been discovered along adjacent nearshore areas including St. Margarets Bay (DFO 2002, Koeller pers. comm. 2003). Shrimp have neither been found, nor are they expected elsewhere along the HRM shore due to the relatively warm waters found in these areas (Koeller pers. comm. 2003).

Shrimp are serial hermaphrodites; They begin life as males and become females at approximately age four. Migrations between inshore and offshore areas near the southern limit of their distribution, such as St. Margarets Bay, are likely due to the marginal conditions of the populations in such areas. These migrations may be necessary for the sustainability of stocks in marginal areas such as Mahone Bay and St. Margarets Bay, but this is not likely true for the main populations elsewhere on the eastern Scotian Shelf (Koeller pers. comm. 2003). Females aged five and up bear eggs between August and April; egg release has been observed both inshore and offshore, suggesting that the inshore/offshore migration of egg-bearing females is conducted in only part of the population (Koeller et al. 1995). The inshore movements may in fact be conducted only by females that are already relatively close to shore when water begins to cool in the fall. If this is the case, then the inshore may not be an exclusive nursery area requiring special protection (Koeller et al. 1995). Alternatively, shrimp found in Mahone Bay and St. Margarets

Bay exhibit faster growth, earlier maturation and smaller maximum size than more northern populations, probably due to increased temperature (Koeller pers. comm. 2003).

Although population abundance of inshore shrimp is not known directly, consistently high landings in NAFO Unit Xm indicate a strong local population in that area, which overlaps SHACI Unit 4 (MFDVDC 2002). There are significant unknowns about the distribution, abundance, and timing of life history events experienced by shrimp in SHACI Units 4-6. Because the St. Margarets Bay population is small and segregated from the main offshore stocks to the east (Koeller pers. comm. 2003), it is unlikely that we will fill these knowledge gaps in the near future.

Ocean quahog (Arctica islandica)

The ocean quahog is a large, subtidal bivalve with a heavy shell, most often found in soft, sandy to muddy bottom areas ranging from 4 to 450 m deep (DFO 1998a). It is often found in the vicinity of other hardshell clams, including propeller clams (*Cyrtodaria siliqua*), Atlantic surf clams (*Spisula solidissima*) and Arctic surf clams (*Spisula polynyma*) (DFO 1987). The ocean quahog is fairly rare inshore, and biological evidence suggests that St. Margarets Bay is the northernmost inlet along the Nova Scotia coast with a noteworthy abundance of this species. Nothing is known, however, about this population, its number, total biomass, productivity or health. An inshore clam survey was planned for this location but could not trawl due to rough bottom, suggesting little potential for commercial development (Rowell and Chaisson 1983). Roddick (pers. comm. 2003) noted that this population has been occasionally fished at times when other beds to the south were temporarily closed due to sewage contamination.

Periwinkle (Littorina littorea)

Periwinkles are marine snails found above and throughout the intertidal zone and subtidally to 40 m in a variety of subtidal habitats. Areas of concentration include the low tide mark, tidal pools, subtidal drift algae and rock crevices (DFO 1998b). They are invariably found in association with rockweed, *Ascophyllum nodosum* (Sharp pers. comm. 2003).

Periwinkles, found throughout the Maritimes, have not been assessed recently, comprehensively, or even locally. Select studies and anecdotal information identify local populations at the following locations: Blandford, Northwest Cove, French Village, Peggy's Cove, Halifax, Three Fathom Harbour, Point Pleasant, Mushaboom Harbour and Sober Island. The latter five locations host commercial size populations – abundant individuals with minimum shell heights of 13 mm and minimum counts of 160 per pound; such areas are rare (MacLeod 1974, DFO 1998b, Sharp pers. comm. 2003). MacLeod (1974) projected that the outer islands along the Eastern Shore would also yield "fair quantities" of periwinkle.

Softshell clam (Mya arenaria)

Softshell clams are widespread along Nova Scotia's Atlantic coast, and may be found on most muddy intertidal beds (Freeman pers. comm. 2003), as well as subtidally and in a range of other sediment types (DFO 1997). Within SHACI Units 4-6, clam beds have been identified through scientific surveys and traditional ecological knowledge. Their locations include Boutilier's Cove and Clam Pond within St. Margarets Bay, Eastern Passage in Halifax Harbour, Cow Bay, Cole Harbour, Petpeswick Inlet, Chezzetcook Inlet, Musquodoboit Harbour, Clam Harbour, Indian Harbour and Three Fathom Harbour (Ingalls 1942, Witherspoon 1982, Mullen and Woo 1985, Woo 1991, GCCRMP 1994, HCESCRMP 1996, HRMWRCRMP 1996, LCCRMP 1996, MIDI 2003). More specific locations are identified within the Coastal Resources Mapping projects produced for the HRM and former Halifax County (HCESCRMP 1996, HRMWRCRMP 1996). Witherspoon (1982) identified 12 important flats within Chezzetcook Inlet, distributed among west Chezzetcook and northeast Chezzetcook areas. Softshell clams typically avoid their preferred habitat where it supports marsh grass and razor clams (Woo 1991).

Despite long-standing harvesting of the softshell clam within Nova Scotia, systematic stock status surveys have not been conducted, and thus status is unknown for much of the province. Likewise, there is very little knowledge regarding local productivity, biomass or trends in either statistic for this species (Freeman pers. comm. 2003). A few specific locations have, however, been studied in detail, particularly Cole Harbour, Chezzetcook Harbour, Three Fathom Harbour, and Clam Harbour, all within SHACI Unit 5. Three Fathom Harbour and Clam Harbour were determined to support higher standing stocks than other areas of Nova Scotia, with densities for pre-recruits (43-50 mm shell length) and recruits (≥51 mm shell length) measuring between 4.2 - 50.9 and 29.6 - 71.3 bushels/hectare, respectively (Mullen and Woo 1985). Mullen and Woo (1985) showed that the proportion of market sized clams varied significantly between adjacent productive beds (Table 10-3).

Table 10-3: Percent of surveyed population attributed to three recruitment categories (Mullen and Woo 1985)

Location	Recruitment Category		
	% Early recruits (0-42 mm)	% Pre-recruits (43-50+ mm)	% Recruits (≥51 mm)
Three Fathom Harbour	97.21	0.50	2.27
Clam Harbour – Area 1	70.41	17.48	12.12
Clam Harbour – Area 2	97.56	0.84	1.61

The reported time from spawning to harvestable shell lengths (51 mm) varies among clam beds between six and eight years (DFO 1997). The commercial stock size of individual clam beds also depends on other dynamic features such as bed area and clam density (Table 10-4). Woo (1991) demonstrated that the density of market-sized recruits increases in closed areas, and that clam beds in Cole Harbour are less dense than other beds throughout Nova Scotia. Clam bed stocks are decreasing throughout Nova Scotia.

Table 10-4: Clam beds and market-size clam statistics

Study	Area	Clam bed surveyed area (ha)	Density (#/m^2)*	Age of recruitment (yr)	Commercial Stock Size (t)
Woo (1991)[a]	Cole Harbour – Open	81.6	0.7 – 15.3	6.0	32.1
	Cole Harbour – Closed	81.6	2.2 – 7.8		29.4
Witherspoon (1982)[b]	Chezzetcook Inlet	56.24	23.2	8.0	251.6*
Mullen and Woo (1985)[c]	Clam Harbour – Area 1	6.52	9.3	6.2	12.67
	Clam Harbour – Area 2	7.16	3.63		5.79
	Three Fathom Harbour	11.0	4.99	6.7	13.85

[a] This study used a recruitment size of ≥50 mm.
[b] This study used recruitment size of ≥49 mm.
[c] This study used a recruitment size of ≥51 mm.
* derived from published figures

Softshell clams in Chezzetcook Harbour spawn between mid-July and mid-August; clams in other bays may do so up to two weeks earlier or later (Witherspoon 1982). Larvae typically remain planktonic for up to five weeks, settling throughout September in Chezzetcook, Sonora, and Petpeswick (Burke and Mann 1974, Witherspoon 1982).

Common whelk (Buccinum undatum)

The whelk is known by a variety of common names: Buckie, waved whelk, rough whelk and common whelk. It is a carnivore and scavenger with a yellowish white to brown shell 3.5- 4 cm in height. In SHACI Units 4-6, *B. undatum* has only been identified at Owls Head and Chezzetcook Harbour (Kenchington and Glass 1998, DFO 1999, MIDI 2003). A 1998 whelk study determined that specimens from Owls Head exhibited greater sexual dimorphism (in six characters) than specimens from 11 other sites throughout the Bay of Fundy or southwest Nova Scotia (Kenchington and Glass 1998). The same study noted that whelks lacked a planktonic dispersal phase, and adults occupied a relatively small home range, suggesting that "local populations may be locally adapted to predators and parasites, with substantial differences in size-at-maturity and yield among populations" (Kenchington and Glass 1998).

Two other species are common and appear to co-exist with the common whelk: *Neptunea decemcostata* and *Colus stimpsoni*. *Neptunea decemcostata*, the ten-ridged whelk, is found at shallower depths (subtidal to about 70 m). In some areas, *Neptunea* is sometimes more common than *B. undatum*. *Colus stimpsoni*, Stimpson's whelk, and the common northern moon snail, *Lunatia heros*, are also harvested with *B. undatum* under DFO's Eastern Nova Scotia Whelk/Moon Snail Integrated Fisheries Management Plan (DFO 1999).

Bait worms

Bait worms are marine worms used for bait in recreational and commercial fisheries. The term is commonly applied to two species in coastal Nova Scotia: bloodworms (*Glycera dibranchiata*) and sand worms (*Nereis virens*). Bloodworms are the more commercially important of the two, and as a result more information is known of this species than any other marine worm in Nova Scotia. No commercial bloodworm harvesting occurs, however, in SHACI Units 4-6, hence its distribution is not well known (Miller pers. comm. 2003, Weber pers. comm. 2003).

Bloodworms occur from the high water mark to ~180 m on a variety of substrates but are most abundant intertidally on estuarine soft muds (softer than occupied by softshell clams), rich in organic matter, their preferred food. Sandworms are found on cleaner soil, typically associated with clam flats (Caddy and Chandler 1976).

Traditional knowledge has identified some locations where bait worms are found throughout SHACI units 4-6, including West Jeddore, Jeddore Harbour and Fisherman's Cove, Eastern Passage in Halifax Harbour. Bloodworms were found only in St. Margarets Bay at Boutilier's Cove and Black Duck Cove. Sand worms were positively identified in St. Margarets Bay at Hubbards Cove, off Cleveland Provincial Park, and at Boutiliers Cove; in Sambro Harbour at Holland Cove and off Sambro Head; at Indian Harbour, Pennant Cove, and Ketch Harbour (within Halifax Harbour) (HRMWRCRMP 1996, HCESCRMP 1996).

Green sea urchin (Strongylocentrotus droebachiensis)

The green sea urchin is common to rocky shallow bottoms throughout eastern Canada waters and found to depths exceeding 400 m (DFO 2000c, Miller and Nolan 2000). In Nova Scotia urchins and their principal food, kelp (*Laminaria* sp.), are typically abundant, concentrated within 20 m depth at exposed shores (Moore and Miller 1983, Miller and Nolan 2000). Urchins and kelp compete for this habitat, undergoing a cycle of alternating abundance regulated by urchin grazing pressure on the seaweed and mortality events experienced by the urchin, particularly disease and fishery mortality (DFO 1996a, Miller and Nolan 2000). The kelp beds provide important habitat for several marine species, making them signficant components of benthic community structure and diversity (Scheibling et al. 1999). The capacity of large urchin feeding aggregations to destroy massive areas of kelp beds and anticipated negative effects on the lobster fishery stimulated DFO scientists to survey over 4900 km of Nova Scotia's Atlantic shoreline. Their aim was to characterize the shoreline and determine the area and locations of habitat shared by urchins and seaweed (Moore and Miller 1983, Moore et al. 1986). Over 40 transects were surveyed within SHACI Units 4-6 identifying 209 km of rocky bottom, 145 km of soft substrate, and a total of 27 km^2 of suitable rocky habitat between Ship Harbour and Liscomb Harbour (Moore et al. 1986). Similar estimates for Ship Harbour west to Blandford were not published. Most of the unsuitable habitats occurred in estuarine areas; major ones in HRM waters included Ship Harbour, Jeddore Harbour, Musquodoboit Harbour, Petpeswick Inlet and Chezzetcook Harbour (Moore and Miller 1983).

Urchin-induced kelp bed destruction leaves large bottom areas without any seaweed, known as urchin barrens (Scheibling et al. 1999). Evidence of these barrens was first documented in St. Margarets Bay during the early 1970s and subsequently along ~500 km (straight-line distance) of Nova Scotia's Atlantic shore (Wharton and Mann 1981). Subsequent research has shown that kelp beds can recover very quickly following sea urchin removal by disease and/or harvest (Mann 1977 and Miller 1985, DFO 1996a). Of the two, disease is far more important, causing 10-100 times the mortality due to the fishery (DFO 2000c).

A series of disease outbreaks among urchin populations have been observed and reported along Nova Scotia's Eastern Shore throughout the past 70 years (Table 10-5). Pennant Bay was among the areas first hit by the 1995 die-off, and during 1995-1999 disease eliminated all the harvest potential in Queens, Lunenburg and Halifax Counties (DFO 2000c, Miller and Nolan 2000).

Table 10-5: Reported history of disease outbreaks affecting harvest size sea urchins within SHACI Units 4-6 (based on data from Moore and Miller 1983, Miller 1985, DFO 1996a, Miller and Nolan 2000)

Time of outbreak	Area affected	Mortality extent, distribution** and tonnage (t)
1930s	West of Halifax	
1950s*	West of Halifax	
1980 – 1981	Halifax and east	Nearly complete, 160 km, 80 000
	Ship Harbour to Liscomb Harbour	Heavy, widespread; total >270 000
		High, patchy
1990-1994	Eastern Shore	100%, 120 km
1995	Port Mouton to Halifax Harbour	100%, scattered
1996 – 1999	Halifax Harbour to Jeddore Harbour	100%, scattered, 2 fronts totalling 160 km
2000	Halifax County W. of Halifax Harbour	100%, widespread 140 km
	Eastern Shore	

*Unconfirmed
** Straight line distance

There is limited biological and fishery information regarding sea urchin distribution and abundance across the HRM coast, and indeed the entire province. The dynamics of the sea urchin – macroalgae abundance cycle accounts for much of this uncertainty because urchin-dominated barrens one year may become productive kelp beds within three years (Scheibling and Hennigar 1997). The habitat based urchin fishery regime is also partially responsible because it replaced the traditional management unit, harvest tonnage, with fishery licences. Consequently the standard statistics available for other fisheries, including biomass, production, and size frequency are not available for urchins (Miller and Nolan 2000). Other unknowns include the accurate amount of landed weights, width of the zone supplying feeding fronts, the rate of urchin movement through this zone required to identify the habitat area supplying the harvest, precise locations of harvest area, percentage gonad yield, and depth fished. Scientists also wish to locate and define the nature of refuges where urchins are protected from disease outbreaks. Finally, acknowledgement of the inherent tendency of sea urchin populations to suffer massive die-offs from disease (Scheibling et al. 1999) has heightened interest in the ability to predict these events.

Non-commercial species

SHACI Units 4-6 are host to dozens of marine invertebrate species, many of which are very productive and fished commercially. Some invertebrates, however, are not fished commercially, although their abundance does not necessarily determine whether or not they are fished. For example, blue crabs are rare and therefore not economically fished. Blue mussels, on the other hand, are very abundant and widely available, but their availability to the market through aquaculture has virtually eliminated the fishery for this species.

In the absence of a fishery, reliable information on local distribution patterns is typically not available, however, sparse anecdotal information and some limited knowledge of depth and habitat preferences can be used to locate concentrations of unfished species.

Blue crab (Callinectes sapidus)

Although blue crab are found in Nova Scotia, it is doubtful that the species successfully completes its life cycle here. Blue crab are not often found north of Cape Cod (Guillory 2001). They prefer estuarine environments with warm water (15 – 33ºC) and low salinity (3-15 ppt) (Zinski 2001). The blue crab that are found in coastal Nova Scotia likely result from warm-water incursions transporting larvae or juveniles from further south. Only 14 blue crab records occur in Nova Scotia within the past 101 years, all within SHACI Units 4 and 5. These include West Lawrencetown Lake (2002), Cole Harbour (1902 & 2001), St. Margarets Bay (1970), Lawrencetown (1954), and Cow Bay (1902 & 1903) (MacDonald 2002).

Blue mussel (Mytilus edulis, Mytilus trossulus)

"Blue mussel" is the common name applied to two closely related mytilid species: *Mytilus edulis* and *M. trossulus*. Both occur throughout Atlantic Canada, and populations of both species can be found intermixed in bays on the Atlantic coast and also in pure populations; some evidence of natural hybridization has been noted (DFO 1996b, Kenchington et al. 2002). The two species are commonly distinguished based on shell shape, although variations in these shapes prevent consistently reliable distinction in mixed populations (DFO 1996b, Kenchington et al. 2002). They may also be distinguished on the basis of salt tolerance: *M. trossulus* is tolerant of a wide range of salt water concentrations, whereas *M. edulis* prefers saltier water. *M. edulis* is typically the numerically dominant species, although some populations, particularly on Cape Breton Island, are mostly *M. trossulus*. Ship Harbour also has a notably high *M. trossulus* population corresponding to its low saline environment (Kenchington et al. 2002, Freeman pers. comm. 2003).

There are very few inshore, hard-bottom areas of Nova Scotia where blue mussels are not found. The preferred habitat of both species is hard bottom in both intertidal and subtidal areas, where they may be found as isolated groups among boulders, attached to underwater structures, or in extensive, gradually sloping beds (DFO 1996b). Mussel beds have been identified at dozens of locations within SHACI Units 4-6 by traditional ecological knowledge (GCCRMP 1994, HCESCRMP 1996, HRMWRCRMP 1996, LCCRMP 1996). Although mussels may be found to maximum depths of 50-60 m, they are more common within 5 m of the surface, with *M. edulis* preferring to settle at 3 m and 5 m depths and *M. trossulus* dominating at ≤1 m (Kenchington et al. 2002, Freeman pers. comm. 2003).

Rising water temperatures and the beginning of the spring phytoplankton bloom initiate reproductive development in late March, which continues through May. The majority of spawning activity occurs between mid-May and mid-June while minor spawning may occur in late summer or fall. Spat settles on solid surfaces approximately five to eight weeks following spawning (DFO 1996b, Schaefer et al. 2003).

Blue mussels are a highly valued shellfish and were previously harvested from wild-caught stock or cultured from wild spat. The hardier shell and greater meat size of *M. edulis* made it the favourite of harvesters and the market; the demand for a consistent product drove production from wild-caught to aquaculture operations so that today very few wild mussels are harvested in Nova Scotia (DFO 1996b, Freeman pers. comm. 2003).

Northern quahog (Mercenaria mercenaria)

The northern quahog, also known as bay quahog, Littleneck, and hard clam, is more common to inshore areas than the ocean quahog (*Arctica islandica*) and prefers soft (sandy, silt and mud) bottoms (DFO 1996c). *M. mercenaria* is usually found in the intertidal zone to subtidal depths of 15 m in its preferred habitats, which it does not share with *A. islandica*. Northern quahogs are only rarely found on HRM shorelines and may exist only in a few small, unidentified pockets (Roddick pers. comm. 2003). There is no potential for a commercial fishery in this area (DFO 1996c).

Razor clam (Ensis directus)

The razor clam *(Ensis directus)* shares its common name with two other species: *Siliqua costata* and *S. squama*. These species are distinguished by shell length; *S. squama* and *S. costata* shells rarely exceed 7.5 cm whereas *E. directus* shells typically exceed 20 cm. *Ensis directus,* also known as the Atlantic jackknife, is found throughout the Maritime Provinces, most commonly on intertidal sand and mud flats, and often among populations of other bivalves such as northern quahogs and bar clams (Kenchington et al. 1998).

Within SHACI Units 4-6, traditional knowledge has identified razor clam populations at the following locations: Chezzetcook Inlet, Sambro Harbour, Prospect Bay, and in the vicinity of Boutilier's Cove, St. Margarets Bay (HCESCRMP 1996, HRMWRCRMP 1996). Due to the difficulty encountered in catching and transporting this clam, it is subject only to low-intensity harvest for personal use by local residents, and little to zero commercial interest (Smith pers. comm. 2003).

Toad crab (Hyas arenias and Hyas coarctatus)

Two species of toad crab are found in Atlantic waters. They are morphologically quite similar, and undifferentiated by fishermen (DFO 1996d). Well-distributed along the Nova Scotia coast, toad crabs concentrate at depths of 50–100 m between lobster and snow crab grounds. They are found within SHACI Units 4-6, although their precise locations are unknown. Little other information is available for Nova Scotian waters, but in Newfoundland moulting occurs between May and September, and females mature at a minimum carapace width of 20-25 mm. Crabs undergo three larval stages before becoming juveniles (DFO 1996d, Tremblay pers. comm. 2003a).

Threats to invertebrates

Ocean dumping

Hard-bottom assemblages that are smothered by dredge spoil from dumping can suffer drastic changes in macroflora and macrofauna. Lobsters and crabs were absent or scarce on dumped sediment since it provides limited shelter and decreases prey availability (Elner and Hamet 1984).

Fishing activities

The fishing gear used to harvest certain species, such as draggers, may harm the bottom habitat used by others. Some fishers claim that scallop dragging has changed the bottom habitat to the point that lobster no longer inhabit certain areas (D. Pezzack pers. comm. 2001).

Rockweed harvesting may have an effect on lobster because rockweed provides shelter. We assume that shelter is critical to young lobster but the specific importance of shelter is still unclear (D. Pezzack pers. comm. 2001).

Overfishing & natural variation

Overfishing could harm invertebrate populations. Even seemingly healthy populations can be threatened by the combination of overfishing and natural pressures. The current boom in lobster recruitment in southwest Nova Scotia is not necessarily attributable to good management practices. Some change in the natural conditions responsible for this boom could threaten lobster in this area, particularly if fishing pressure remains high (D. Pezzack pers. comm. 2001).

Biological invasions

Introduced species, such as the seaweed *Codium*, may affect lobster habitat. The invasive green crab also impacts invertebrates. This species is becoming more abundant everywhere in Nova Scotia and its increased population is affecting nearshore community structure.

Oil and gas industry

Seismic
Seismic noise is known to have deleterious effects on fish and marine mammals. Its effect on invertebrates, however, is largely unknown. Shellfish lack anatomical structures suited for detecting sound waves but some seem able to detect vibrations. Kenchington (2001) takes the precautionary approach and assumes that shellfish would react to seismic noise similarly to fish; they would either swim away to avoid the disturbance, or seek cover and reduce foraging activities.

Drilling discharges

Drilling produces various types of discharges which are described and discussed extensively by Boudreau and others (2001) and Kenchington (2001). Cuttings are the fragments of bedrock that the drill removes when creating the hole that constitutes the well. As part of the drilling, the cuttings are coated with muds which may be oil-based (OBM), alternative oil-based (ABM), synthetic oil-based (SBM), or water based (WBM).

When discharged at sea, all cuttings accumulate in piles that extend for several kilometres from the drilling site and smother all benthic life beneath. Sessile benthic marine invertebrates would obviously be unable to avoid smothering by cuttings. Also, any cuttings discharged on muddy bottoms would lead to a change in community structure (Kenchington 2001).

The oiled cuttings piles resulting from the use of OBMs, ABMs and SBMs may cause serious local environmental effects since the toxicity of the oiled sediments can remain for several years. Although WBMs do not contain toxic oils, they are not benign. WBMs contain various toxic chemicals including barite and bentonite which are known to have toxic effects on molluscs. Sea scallops are particularly sensitive to bentonite, which glues-up the feeding apparatus of some filter feeders (Cranford and Gordon 1992, Cranford 1995, Cranford et al. 1999). The ecological effect of barite is unclear but it is known to be toxic and persistent in the environment and to cause growth suppression and death in bivalve molluscs (Cranford et al. 2001).

Blowouts and spills

Although very unlikely, blowouts and spills are a potential threat to the marine environment. Subsea gas blowouts cause hydrocarbons to be dispersed in the water column. The consequences of subsea oil blowouts are even more serious, and can lead to severe damage to shorelines and thus intertidal invertebrates.

There are many documented examples of the detrimental effects of oil washing ashore, most of which are related to the shipping industry. Regardless of the specific vector, oil spills can leave large areas completely devoid of animal life. Gradually, these areas are repopulated by opportunistic, pollution tolerant species such as the worm *Capitella capitata* (Howarth 1981), and eventually the benthic fauna may return to its pre-spill composition. Nonetheless, the chronic effects of oil pollution may still be felt. For example, years after a small oil spill in coastal Massachusetts, fiddler crab populations were severely reduced since juveniles in oiled sediments dug burrows too shallow to protect themselves from winter freezing, and adults suffered deleterious, oil-induced behavioural and locomotor responses (Krebs and Burns 1977). In Sydney Bight, the subsurface plume caused by either blowouts or spills could seriously harm the plankton community, including the eggs and larvae of many invertebrate species (Kenchington 2001).

Oil spills, and even chronic, low-level discharges of oil can cause significant bottom contamination. This may occur when oil washes to the intertidal, or at sea when oil quickly passes through the water column to the sea floor and into bottom sediments (Sanders and Jones 1981). In the water column, some zooplankton species feed on oil particles which then collect in their fecal pellets. When the pellets sink to the bottom, so does the oil. Oil can also reach the bottom when it is absorbed by particles suspended in the water column that later sink. In these manners, oil can quickly collect on the bottom in large quantities, and studies have shown sediment contamination around oil platforms even in the absence of major spills (Howarth 1981). Such oil contamination of benthic habitat has detrimental effects on marine invertebrates.

Known effects of oil on marine organisms include the accumulation of hydrocarbon compounds in the tissues. These hydrocarbons are taken in through the gills, and tend to lodge in the fatty tissues such that more contamination is found in marine organisms than in the water. This type of contamination poses a serious human health risk since some contaminant hydrocarbons are carcinogenic. Coastal fisheries can be significantly affected as even a small spill can contaminate shellfish beds for over 10 years (Howarth 1981).

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11 - Fish

Marine fish

Many fish species inhabit the coastal waters of SHACI Units 4, 5 and 6. These include groundfish, such as flounder, pollock, halibut, haddock, cod; pelagic fish, such as tuna, herring, mackerel, swordfish; and diadromous fish, such as salmon, perch, smelt, eel, gaspereau, trout, bass, tomcod and shad (Halifax County-Eastern Shore Coastal Resources Mapping Project [HCESCRMP] 1996, Halifax Regional Municipality (Western Region) Coastal Resources Mapping Project [HRMWRCRMP] 1996). Some fish make seasonal migrations in and out of the area using the coastal waters as spawning, nursery or overwintering areas. Others are resident year round.

SHACI Units 4, 5 and 6 roughly correspond with several fisheries management and jurisdictional boundaries. SHACI Unit 4 lies within the North Atlantic Fisheries Organization (NAFO) fishing division 4X, and SHACI Units 5 and 6 lie roughly within NAFO division 4W. The coastal subunits of NAFO divisions 4W and 4X are called 4Wk and 4Xm. 4Wk roughly corresponds with SHACI Units 5, 6 and 7, while NAFO division 4Xm roughly corresponds with SHACI Units 3 and 4 (Figure 11-1). There is no NAFO subdivision exclusive to SHACI Units 4, 5 and 6. Halifax County boundaries also roughly correspond with SHACI Units 4, 5 and 6 (Figure 11-1).

Commercial fish species on the Scotian Shelf are well studied. Less information exists regarding fish populations and habitats in inshore areas. DFO conducts regular fish surveys that generally occur beyond 25 km from shore and at depths greater than 50 fathoms (91.4 m).

Since 1995, the DFO 4VsW sentinel survey has sampled fish in coastal waters ranging from 37-154 m in depth. This survey is conducted in the fall using longline gear that is set on a variety of substrate types. At least 19 different fish species have been caught in this survey (Table 11-1). This list does not represent the extent of fish species present in coastal waters of SHACI Units 4, 5 and 6 since the sampling method limits catches to demersal piscivorous or omnivorous fish generally over 35 cm in length. As a result, no pelagics, planktivores or detritivores are sampled (Fanning pers. comm. 2002).

Significant fish habitats are those areas considered important for spawning, juvenile development, summer feeding or overwintering. Such significant areas are known in SHACI Units 4, 5 and 6. Information on fish species in this area is provided below.

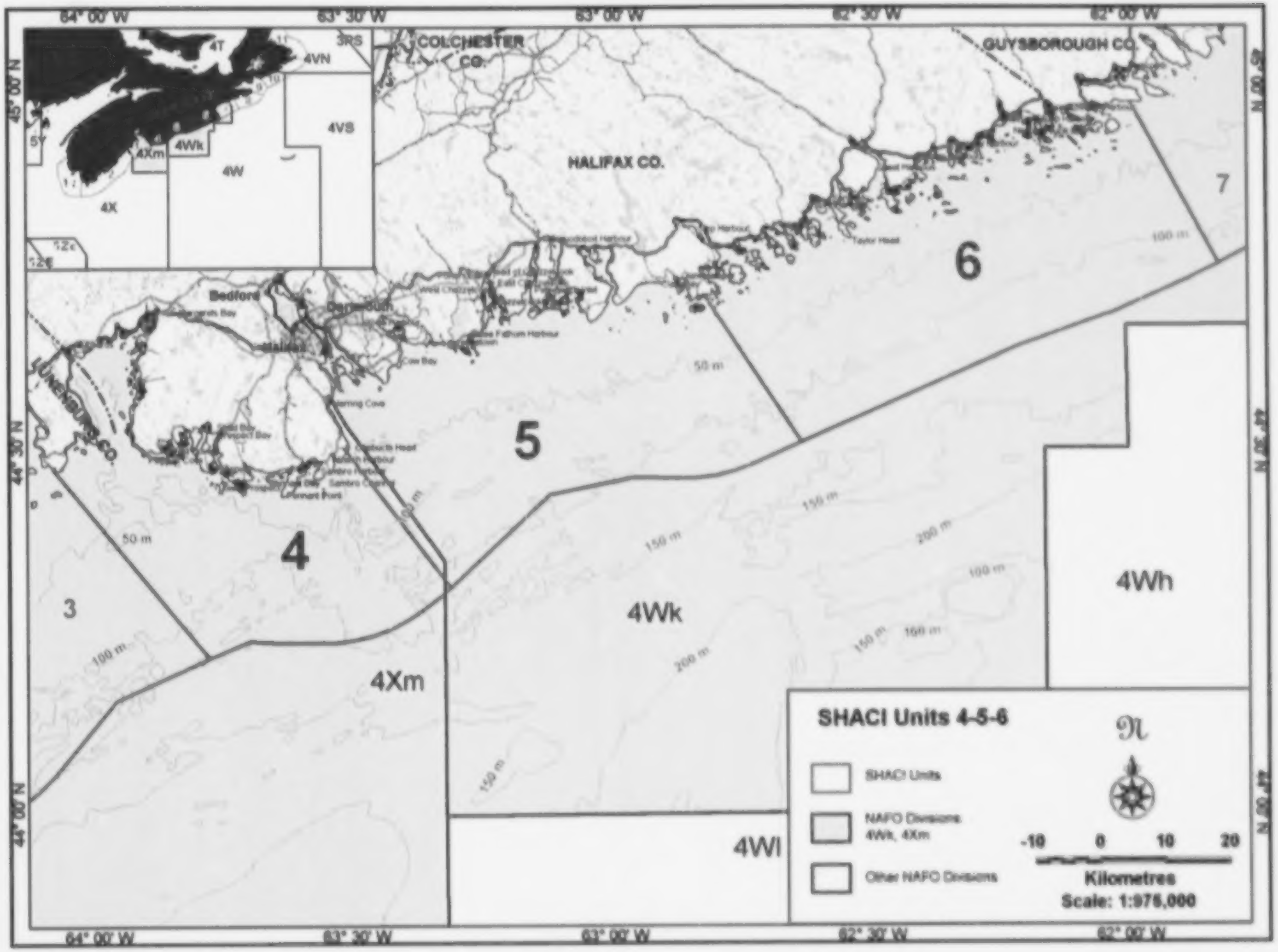


Figure 11-1: SHACI Units 4, 5 and 6, NAFO Units 4Xm and 4Wk boundaries, and Halifax County lines. Inset map of Atlantic Coast NAFO Divisions. Basemap layers (NSGC).

Table 11-1: Fish species caught off Halifax County in DFO 4VsW fall sentinel surveys (1995-2001)

Common name	Species name
Cod (Atlantic)	*Gadus morhua*
Haddock	*Melanogrammus aeglefinus*
White hake	*Urophycis tenuis*
Pollock	*Pollachius virens*
Redfish (unseparated)	*Sebastes sp.*
Halibut (Atlantic)	*Hippoglossus hippoglossus*
Turbot, Greenland halibut	*Reinhardtius hippoglossoides*
American plaice	*Hippoglossoides platessoides*
Winter flounder	*Pseudopleuronectes americanus*
Striped Atlantic wolffish	*Anarichas lupus*
Spotted wolffish	*Anarichas minor*
Northern wolffish	*Anarhicas denticulatus*
Wolffish (unidentified)	*Anarhichadidae F.*
Greenland cod	*Gadus ogac*
Thorny skate	*Raja radiata*
Little skate	*Raja erinacea*
Spiny dogfish	*Squalus acanthias*
Blue shark	*Prionace glauca*
Longhorn sculpin	*Myoxocephalus octodecemspinosus*
Shorthorn sculpin	*Myoxocephalus scorpius*
Sculpins	*Cottidae F.*
Twohorn sculpin	*Icelus bicornis*
Sea Raven	*Hemitripterus americanus*
Arctic alligatorfish	*Aspidophoroides olriki*
Conger eel	*Conger oceanicus*
Wrymouth	*Cryptacanthodes maculatus*
Ocean pout (common)	*Macrozoarces americanus*
Arctic eelpout	*Lycodes reticulatus*
Eelpout (NS)	*Lycodes sp.*

Cod

Atlantic cod are found inshore or offshore depending on the season and play an important role in the marine ecosystem. Found all along the coast in SHACI Units 4, 5 and 6 (HCESCRMP 1996, HRMWRCRMP 1996), cod prey upon a range of species from different trophic levels depending on their age. They are also preyed upon by a variety of other fish species and marine mammals depending on their life stage (Scott and Scott 1988). Cod found in SHACI Units 4, 5 and 6 are managed as part of the 4VsW and 4X/5Y cod management units (DFO 2001a).

4W

DFO research surveys in 4W indicate that throughout the year, most cod are found offshore on Western, Sable and Emerald Banks. Cod are also found closer to shore. The DFO Sentinel survey, conducted in September and October, indicates that there are concentrations of cod in nearshore areas, at least during the fall (DFO 1998a).

The cod fishery in 4W has been closed to directed fishing since 1993. Despite fishery closures, research surveys indicate that cod populations in 4W are low in abundance, and there has been no indication of major recruitment events in recent years. The productivity of this cod stock is also very low and the spawning stock biomass continues to decline (Fanning et al. 2003).

There are several reasons postulated for the poor state of this cod stock. Although no longer caught in a directed fishery, cod continues to be caught as bycatch, both reported and discarded, in other fisheries. Bycatch is thought to pose a serious threat to the recovery of cod stocks. Other factors limiting recovery include the direct and indirect effects of harsh environmental conditions and predation by grey seals. Environmental conditions, namely the colder waters present on the eastern Scotian Shelf from 1986 to 1999 (Drinkwater et al. 2002), are thought to have induced poor conditions resulting in reduced survivorship and low reproductive success (Fanning et al. 2003). Predation by seals may have accounted for the yearly removal of 5400 to 22 000 t of cod (DFO 1998a). However, more recent work indicates that removals may be considerably lower (e.g., 3100 t) (Fanning et al. 2003). Despite more than 10 years of virtually no fishery and a recent return to normal environmental conditions, cod in 4W are continuing to decline (Fanning et al. 2003). In summary, the short-term prospects for a cod population able to support a fishery in 4W remain dismal (DFO 2001a).

4X

4X lies on the western Scotian Shelf. Cod stocks in 4X are in better shape than those found eastward, and were not affected by the 1993 cod moratorium. Research in 4X indicates that there are strong 1998 and 1999 year classes of cod in this area that will contribute to future biomass (DFO 2000a, Clark and Hinze 2003).

Spawning areas

Off Nova Scotia there are several major offshore cod spawning groups as well as a chain of smaller coastal spawning groups. The coastal spawning areas include both spring and fall spawning cod (DFO 2001a).

Brander and Hurley (1992) examined the distribution of early stage cod eggs on the Scotian Shelf using data from the Scotian Shelf Ichthyoplankton Programme (SSIP). They found that spring spawning occurred over most of the Scotian Shelf, and in greatest amounts on the offshore banks. Fall spawning, however, occurred from the Gully, across Middle Bank, and into the inshore areas near, and west of, Halifax. Gagné and O'Boyle (1984), using SSIP data for late stage cod eggs, found that spring spawning occurs in all coastal areas, perhaps starting south of Halifax in March. Late fall and/or early winter spawning was also evident in all coastal areas, and may be more important than spring spawning off Halifax and on the South Shore. Gagné and O'Boyle (1984) found no cod eggs along the coast of mainland Nova Scotia in September and October or in January and February. Hanke et al. (2000) noted the presence of stage III and IV cod eggs, and cod larvae (1-7 mm) off of Three Fathom Harbour in November-December although this was not considered to be a major spawning area for cod.

McKenzie (1940) noted intensive spawning of cod in Halifax Harbour from about October 10 until mid-November. In addition, cod larvae (3-4.9 mm and 3-6.9 mm) were found east of

Halifax in October and November, respectively. Larvae were also found in St. Margarets Bay and from Halifax Harbour to the Bay in November. McKenzie considered Halifax Harbour and St. Margarets Bay to be highly productive autumn spawning areas for cod.

Trippel (2002) identified several coastal cod spawning areas using traditional ecological knowledge (TEK) collected through interviews with fishermen between 1996 and 1997 (Figure 11-2). Both offshore spawning areas and those located within the SHACI study boundaries are indicated in Figure 11-2. Table 11-2 includes the comments collected by Trippel (2002) which are associated with each spawning area that lies within the SHACI study boundaries. In some cases, the comments indicate the timing of the spawning event (season or year) or the past/current condition of the spawning habitat.

Table 11-2: Comments associated with cod spawning areas in SHACI Units 4, 5 and 6 (Trippel 2002)

Map id	Approximate location	Associated comments
A	St. Margarets Bay	November-February
B	Hartlen Point to Three Fathom Harbour	January-April. 1982-1985
C	Darby Bank	Ripe after Herring. Late winter.
D	Prospect to Quoddy Harbour	October-December (?)
E	Off Pope's Head	June-July
F	From off Necum Teuch eastward	August–September. Before draggers fished area.

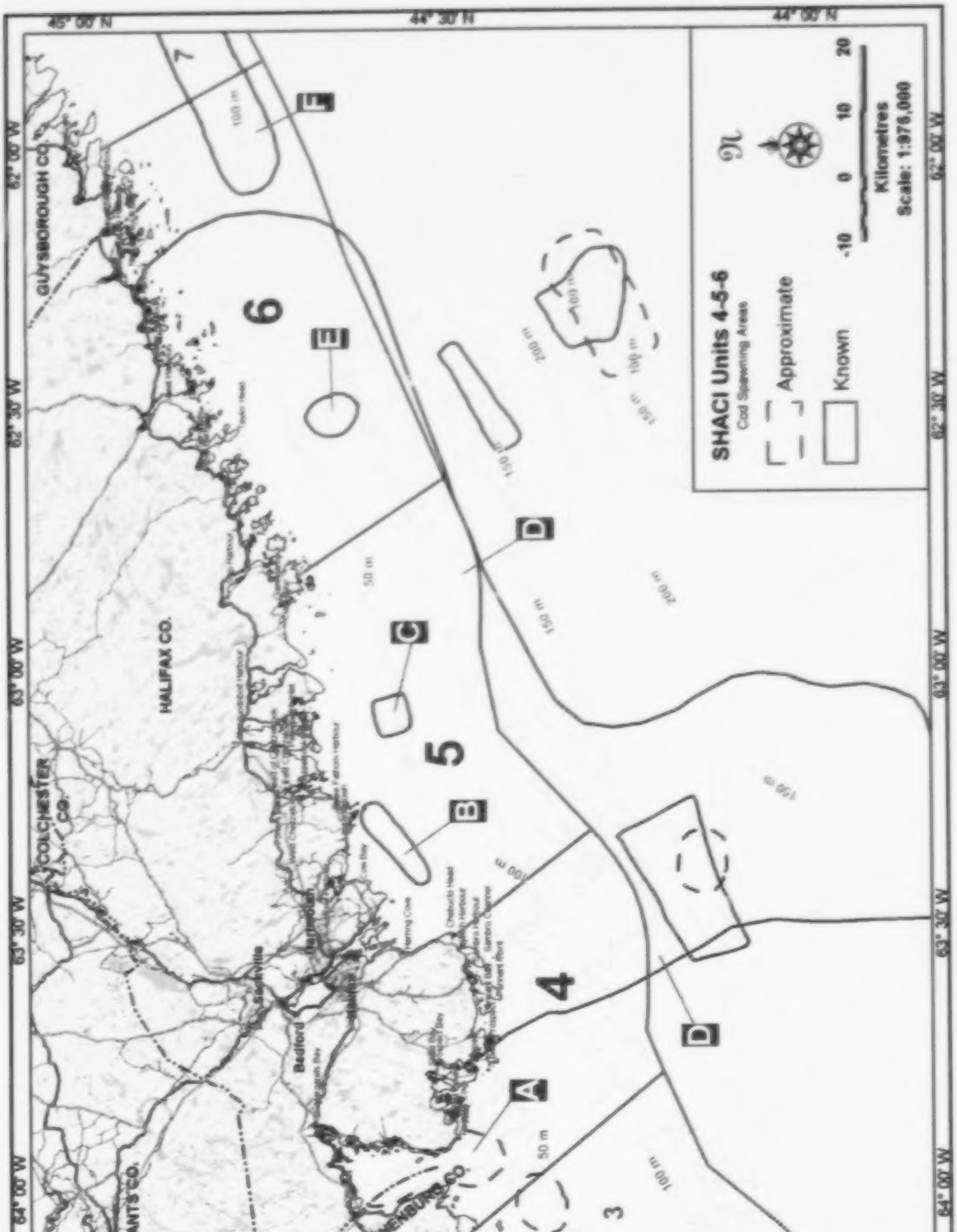


Figure 11-2: Cod spawning areas in SHACI Units 4, 5 and 6 (based on data from Trippel 2002). Basemap layers (NSGC).

Juvenile areas
Juvenile cod are found throughout the coastal areas in SHACI Units 4-6 (Clark pers. comm. 2005). Tupper and Boutilier (1995) showed that survival and juvenile densities of postsettlement cod (< 60 mm) in St. Margarets Bay were higher in more structurally complex habitats. They concluded that the population structure of Atlantic cod in St. Margarets Bay may be less influenced by patterns of larval supply than by postsettlement processes such as habitat-specific growth and mortality.

Trippel (2002) identified one juvenile cod area in SHACI Units 4, 5 and 6 (Figure 11-3). This area off Taylor Head is small in comparison to larger offshore juvenile cod areas. Trippel (2002) reports that this inshore juvenile area existed in 1988-1989, and that cod longlining also occurred in this area.

Gagné and O'Boyle (1984) examined the distribution of cod larvae and found its distribution similar to that of cod eggs in coastal areas. While no larvae were found along the coast of Nova Scotia in early fall or January, larvae were abundant off Halifax and the South Shore in November and December. They concluded that rather than drifting from spawning to nursery grounds, cod larvae are generally retained within large areas where both spawning and nursery areas occur.

Pollock

Pollock are found all along the coast of SHACI Units 4, 5 and 6 (HCESCRMP 1996, HRMWRCRMP 1996). Juvenile pollock (also called "Harbour" pollock) are closely associated with nearshore habitats, and recruit to the offshore populations at approximately age 2 (DFO 2001a).

Spawning areas
Hanke et al. (2001) noted the presence of pollock eggs in inshore waters between Pennant Bay and Three Fathom Harbour in November and December. Traditional ecological knowledge gathered by Trippel (2002) indicates the presence of former pollock spawning grounds in several areas off SHACI Units 4, 5 and 6 (Figure 11-4). Table 11-3 includes the comments collected by Trippel (2002) which are associated with each spawning area within the SHACI study boundaries.

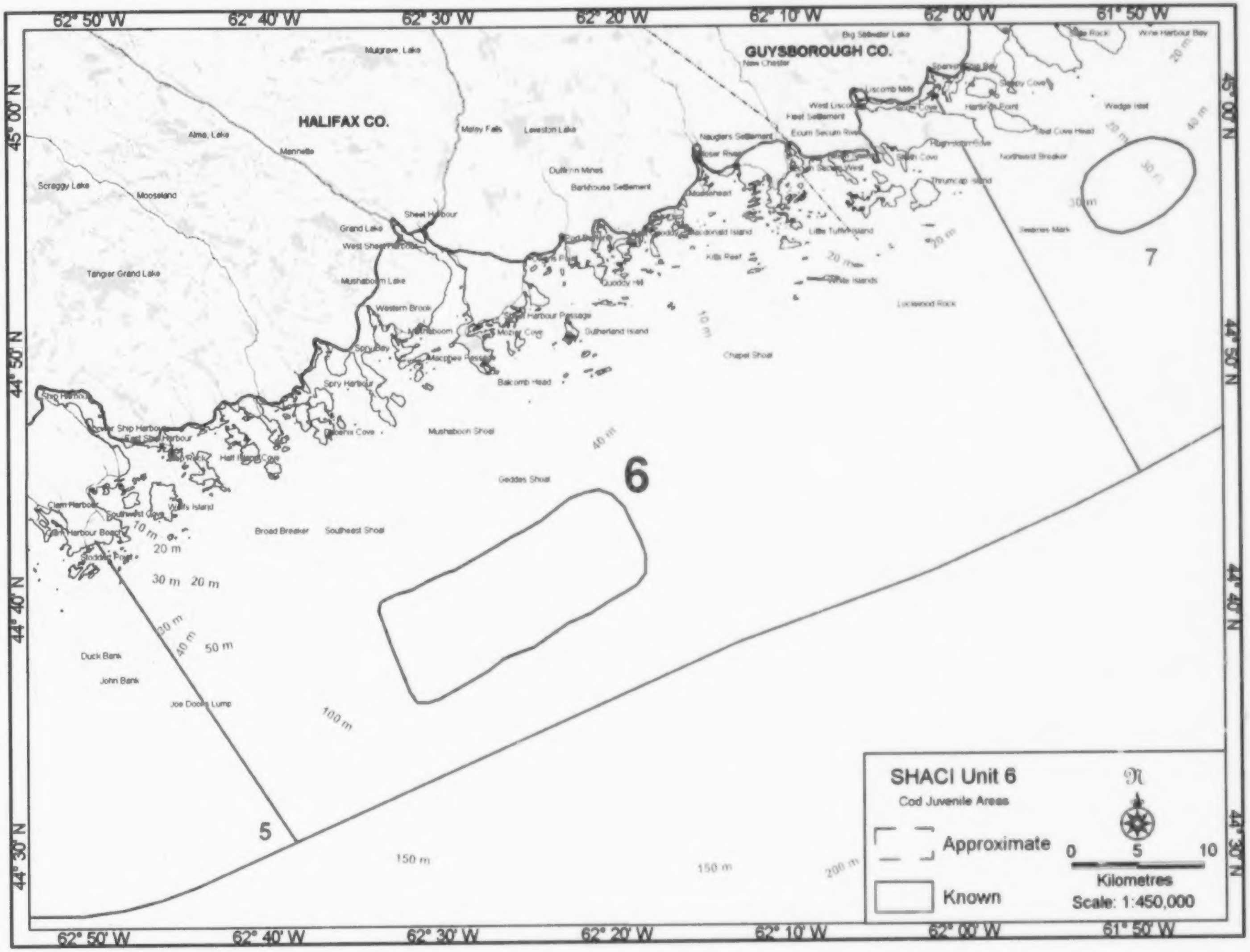


Figure 11-3: Cod juvenile areas in SHACI Unit 6 (based on data from Trippel 2002). Basemap layers (NSGC).

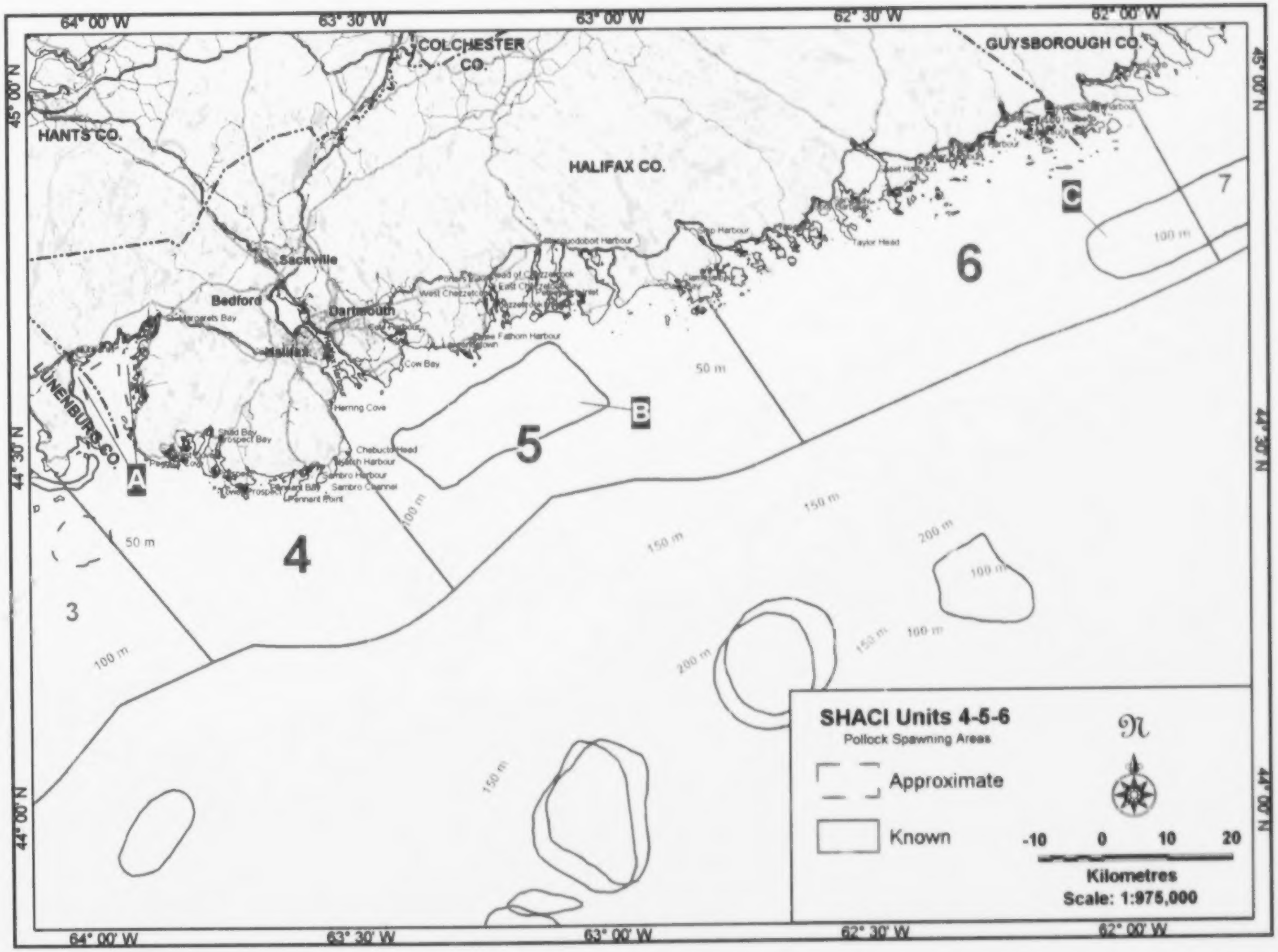


Figure 11-4: Pollock spawning areas in SHACI Units 4, 5 and 6 (based on data from Trippel 2002). Basemap layers (NSGC).

Table 11-3: Comments associated with pollock spawning areas in SHACI Units 4, 5 and 6 (Trippel 2002)

Map id	Approximate location	Associated comments
A	St. Margarets Bay	December. 1970s. "on shore" "not now".
B	Off Halifax Harbour to off Petpeswick Inlet	Ripe 15–20 years ago
C	From off Necum Teuch eastward	Pollock questionable. Before draggers fished area.

Juvenile areas

Trippel (2002) reports a pollock juvenile area along the coast in the vicinity of St. Margarets Bay. In 1996, juveniles had been seen in this area for the past three to four years (Figure 11-5). Trippel (2002) noted that while these juveniles should be moving offshore, they were not appearing elsewhere, and that the number of juvenile pollock had declined in inshore areas (Trippel 2002).

Haddock

Haddock live in cool temperate waters from the inshore to the edge of the continental shelf (Scott and Scott 1988). They are primarily benthic fish, and occur over hard, smooth, sand or gravel bottoms. Haddock generally prefer temperatures above 2ºC and will maintain a similar range of temperatures by seasonally altering their depth distribution from shallow banks in the summer to deeper water in winter (Scott and Scott 1988). Haddock are found most commonly at depths between 46-137 m (DFO 2001a).

There are haddock stocks in the southwestern Scotian Shelf and Bay of Fundy area (NAFO Divisions 4X/5Y) and in Division 4TVW (Figure 11-1). Haddock found in the coastal NAFO subdivision 4Xm belong to the 4X/5Y stock. Although haddock do make seasonal migrations, there is relatively little exchange between adjacent haddock stocks (DFO 2001a).

Spawning areas

In Nova Scotian waters in Division 4X, the major haddock spawning area is on Browns Bank where spawning occurs from April to June (DFO 2001a). In Division 4TVW, principle spawning areas are Emerald, Western and Sable Island Banks (Frank et al. 2001). Coastal haddock spawning areas also exist. Traditional ecological knowledge collected by Trippel (2002) indicates the presence of haddock spawning in several locations (Figure 11-6). Table 11-4 includes the comments collected by Trippel (2002) that are associated with each spawning area within the SHACI study boundaries.

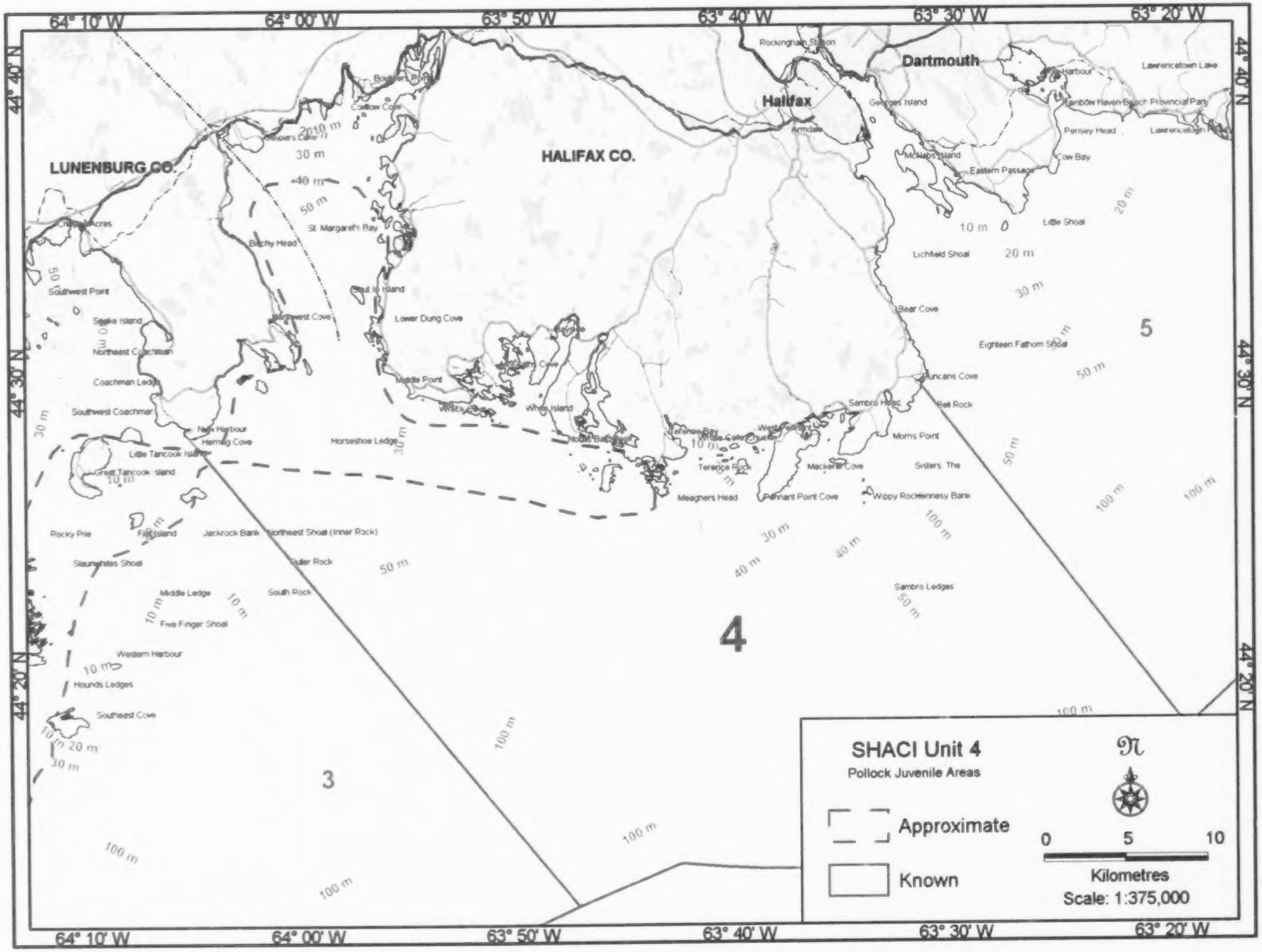


Figure 11-5: Pollock juvenile areas in SHACI Unit 4 (based on data from Trippel 2002). Basemap layers (NSGC).

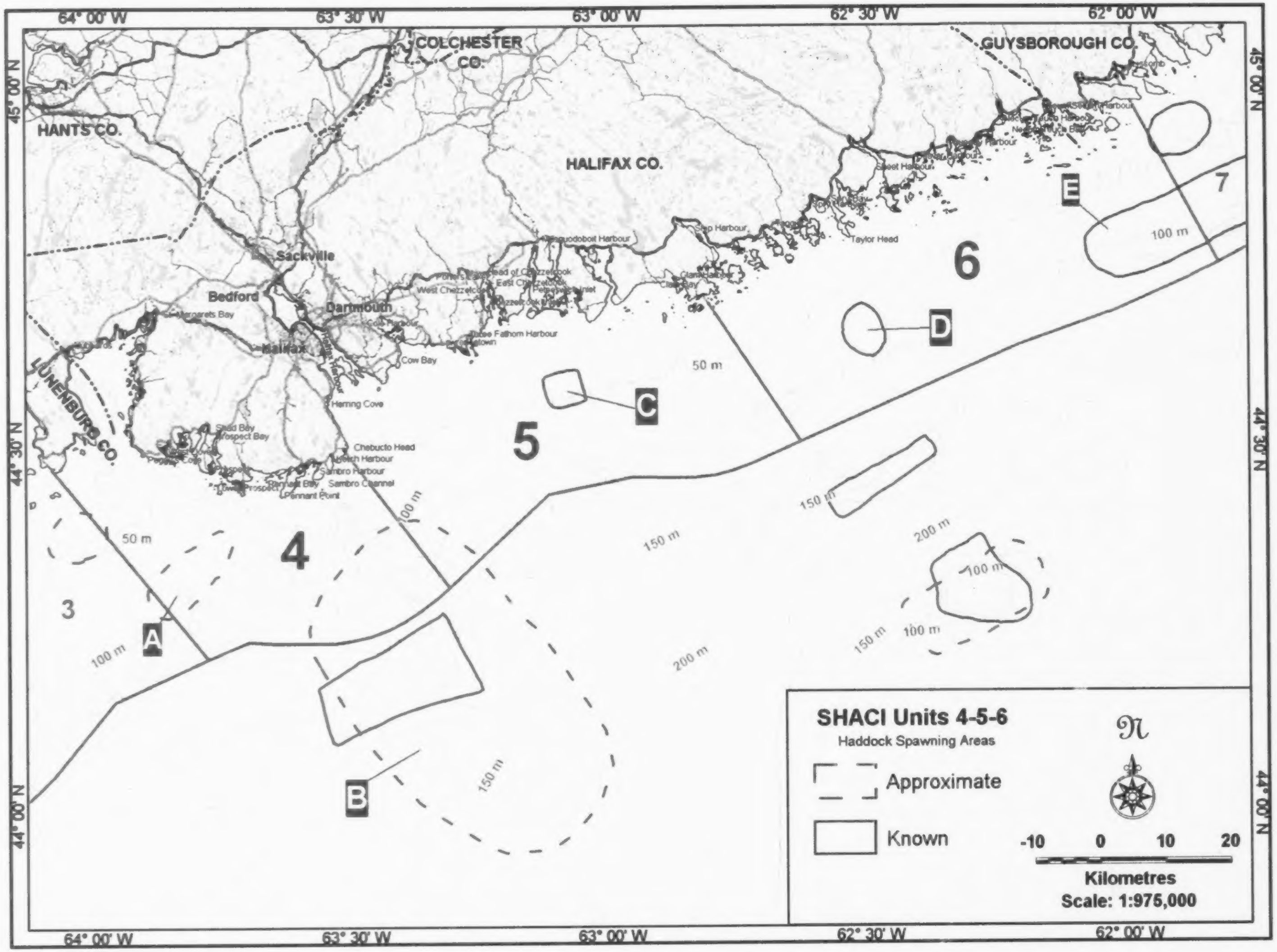


Figure 11-6: Haddock spawning areas in SHACI Units 4, 5 and 6 (based on data from Trippel 2002). Basemap layers (NSGC).

Table 11-4: Comments associated with haddock spawning areas in SHACI Units 4, 5 and 6 (Trippel 2002)

Map id	Approximate location	Associated comments
A	Off Shad Bay	Late November
B	Off Chebucto Head	January-March
C	Darby Bank	Ripe after herring late winter
D	Off Popes Harbour	September
E	From off Necum Teuch eastward	August to September. Before draggers fished the area.

Juvenile areas

Juvenile haddock are concentrated on Emerald, Western and Sable Island Banks (Frank et al. 2001). Trippel (2002) also identified juvenile haddock in coastal areas off SHACI Units 4, 5 and 6 (Figure 11-7). According to TEK, the juvenile areas off Jeddore Harbour and the large area between East Head and Taylor Head were once more extensive and contained more juveniles (Trippel 2002).

Redfish

Redfish are benthic species that live over rocky or silt-clay bottom in cool areas (3-8°C). Generally not considered coastal species, redfish are common along the slopes of banks at depths from 100–700 m (DFO 2001a), however, they do occur in small numbers in inshore areas (Kenchington 1984). In the summer, redfish are abundant along the edge of the Shelf from Sydney Bight to Sable Island Bank, and in lesser abundance to the tail of Browns Bank (Kenchington 1984). There does not appear to be a detectable seasonal difference in the distribution of redfish on the Scotian Shelf. In SHACI Units 4, 5 and 6, redfish were found by the DFO 4VsW sentinel survey that samples fish in coastal waters ranging from 37-154 m in depth (Fanning pers. comm. 2002).

The redfish found in SHACI Units 4, 5 and 6 are considered part of the DFO Unit 3 redfish management region. Unit 3 encompasses NAFO divisions 4WdehklX (Figure 11-8). Two species of redfish, *Sebastes fasciatus* and *S. mentella*, are found on the Scotian Shelf; however, recent research indicates that *S. fasciatus* is the dominant species in Unit 3. This stock is also separate from those inhabiting the southern Gulf of St. Lawrence (DFO 2001a).

Spawning and juvenile areas

Redfish are unusual among other fish in that fertilization is internal and females bear live young (i.e., viviparous, Murua and Saborido-Rey 2003). Redfish are believed to mate in the fall and to release their young sometime between April and July (DFO 2000b). Specific local areas where copulation and/or larval extrusions occur off Nova Scotia are unknown. Females do not appear to undertake seasonal migrations and simply release larvae throughout their range over a prolonged season of three to four months (Kenchington 1984). Breeze et al. (2002) presented redfish larval distributions using data from the SSIP. These data indicate large concentrations of redfish larvae off Chebucto Head and southward along the 50 m contour line. These larval concentrations may indicate the presence of spawning in this area. On the Scotian Shelf, redfish larvae were sampled fairly widely between March and October with peak abundances in March and again in July (O'Boyle et al. 1984).

Juveniles are broadly dispersed on the Scotian Shelf rather than aggregated onto specific nursery grounds (Kenchington 1984). Benthic pre-recruit redfish appear to occupy a similar habitat to that of their parents but in shallower waters (Magnusson and Magnusson 1975, Mayo 1980, Lilly and Gavaris 1982).

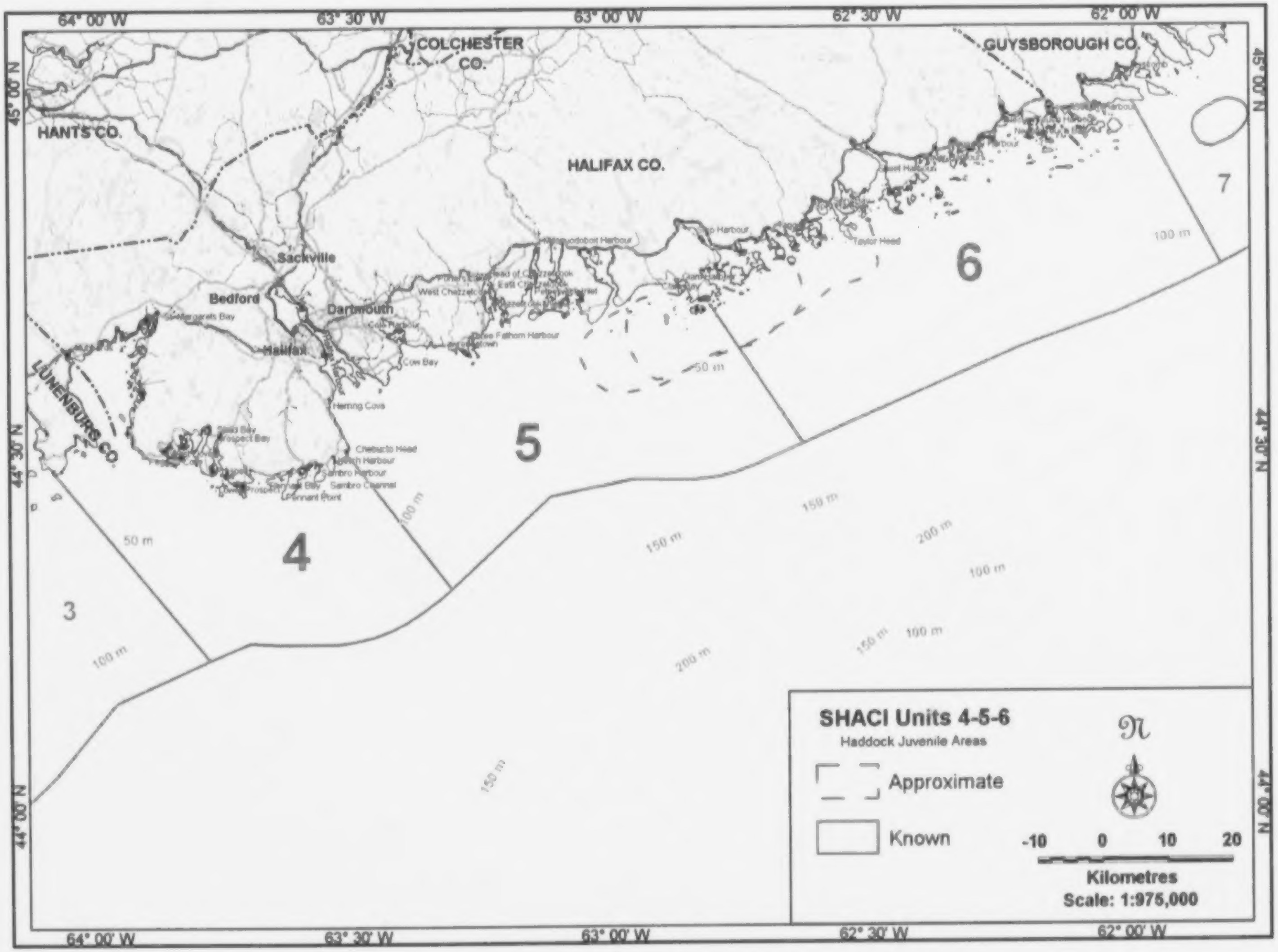


Figure 11-7: Haddock juvenile areas in SHACI Units 4, 5 and 6 (based on data from Trippel 2002). Basemap layers (NSGC).

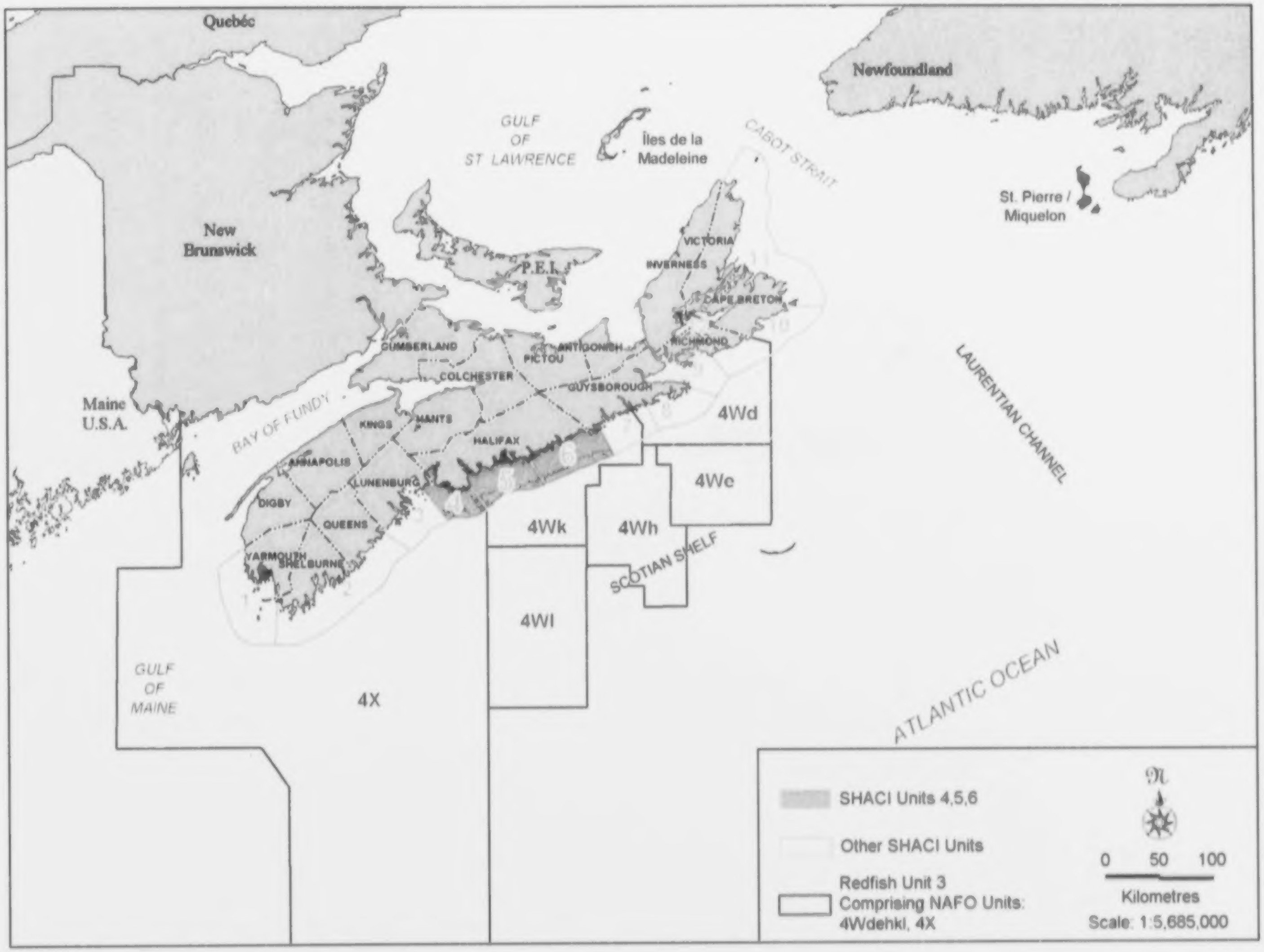


Figure 11-8: Redfish Mangement Unit 3 (DFO). Basemap layers (NRCan).

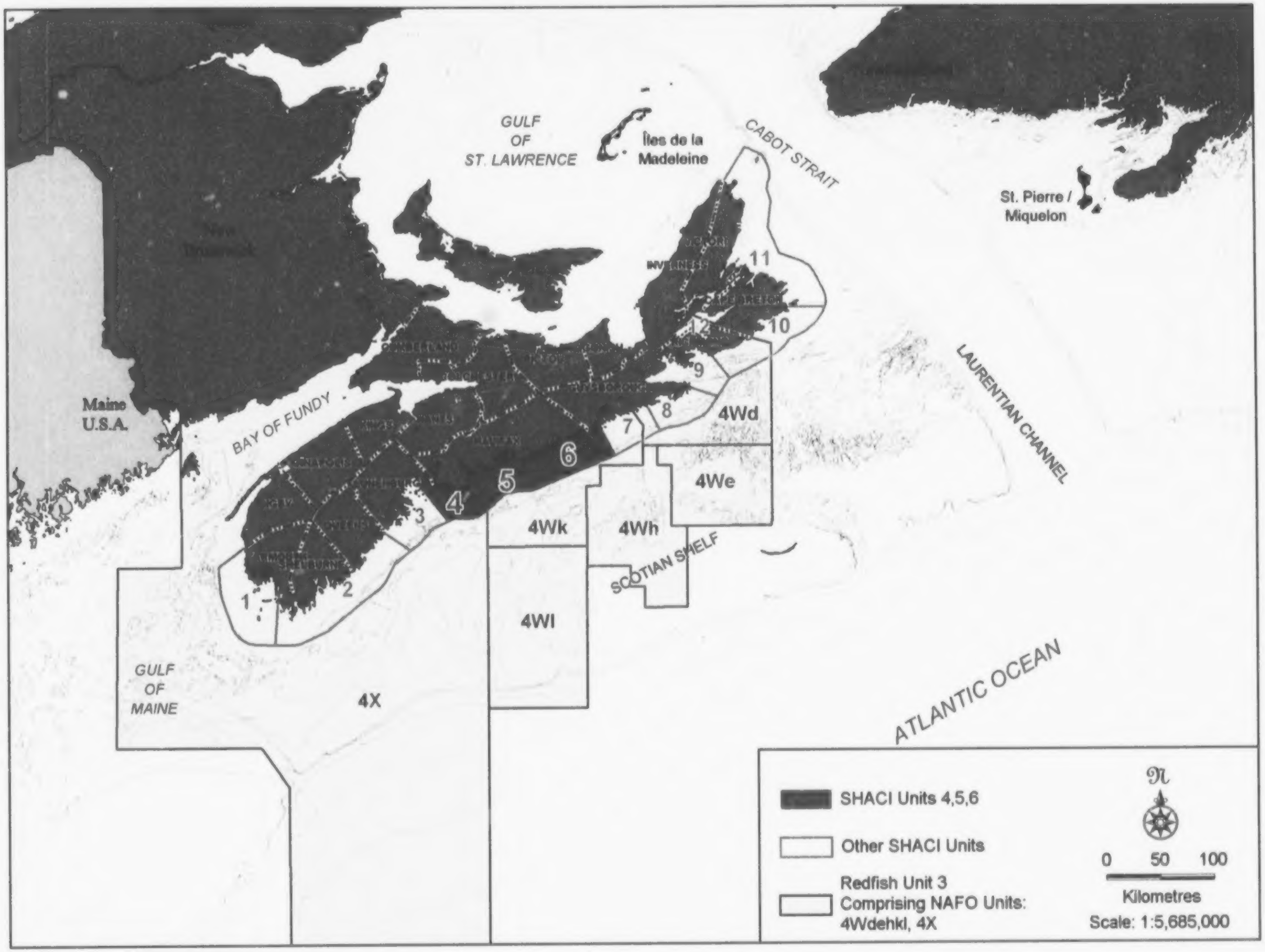


Figure 11-8: Redfish Mangement Unit 3 (DFO). Basemap layers (NRCan).

Silver hake

Silver hake (*Merluccius bilinearis*) occur at a wider range of depths than other gadiform species such as cod, haddock and pollock. They are found from shallow coastal waters to depths exceeding 910 m (Scott and Scott 1988). On the Scotian Shelf, they are generally found between temperatures of 7°-10°C. The distribution of silver hake changes seasonally. During the summer, they inhabit shallower areas on the offshore banks, and then they move to deeper waters in the winter as shallow waters cool (Scott and Scott 1988).

Spawning and juvenile areas
Off Nova Scotia, silver hake are known to spawn on Sable and Western Banks from June to September and also further east on Banquereau Bank (DFO 1999a, Scott and Scott 1988). Waldron (1988) noted that the highest abundance of silver hake eggs, suggesting the location of spawning areas, was found on the Scotian Shelf during the summer on Western and Emerald Banks and the waters in between.

Coastal spawning and juvenile areas may also exist. Waldron (1988) noted that small concentrations of juveniles were found along the coast of Nova Scotia in the summer and fall. In U.S. coastal areas of the North Atlantic, silver hake eggs and larvae have been found at depths as shallow as 10 m, and typically from depths between 50-150 m (Morse et al. 1999). As well, several other reports document the presence of silver hake eggs and larvae, although in low numbers, in nearshore and estuarine environments (Perlmutter 1939, Merriman and Sclar 1952, Virginia Institute of Marine Science Fisheries Laboratory 1961, Herman 1963, Bourne and Govoni 1988). In the U.S., juvenile silver hake are found at depths ranging from 5-350 m and prefer shallow depths (25-75 m) in the autumn (Morse et al. 1999).

According to TEK, hake spawning occurred in two areas of SHACI Units 5 and 6 (Figure 11-9) (Trippel 2002). The various comments associated with spawning area A are presented in Table 11-5. No comments were associated with spawning area B.

Table 11-5: Comments associated with hake spawning area A in and adjacent to SHACI Units 5 and 6 (Trippel 2002)

Approximate location	Associated comments
Off Clam Bay	October-November. 1980's "not there now"
Various locations further offshore than the boundary of Unit 6	August-September. Medium sized fish August-September June-August. 1964-1980s July?

Trippel's (2002) data also indicate a hake juvenile area extending eastward off Necum Teuch (Figure 11-10). This juvenile area is reportedly smaller than it was in the 1980s. Trippel's (2002) information does not distinguish between the different hake species found off the coast of Nova Scotia; therefore this reported site could be a former white hake spawning area.

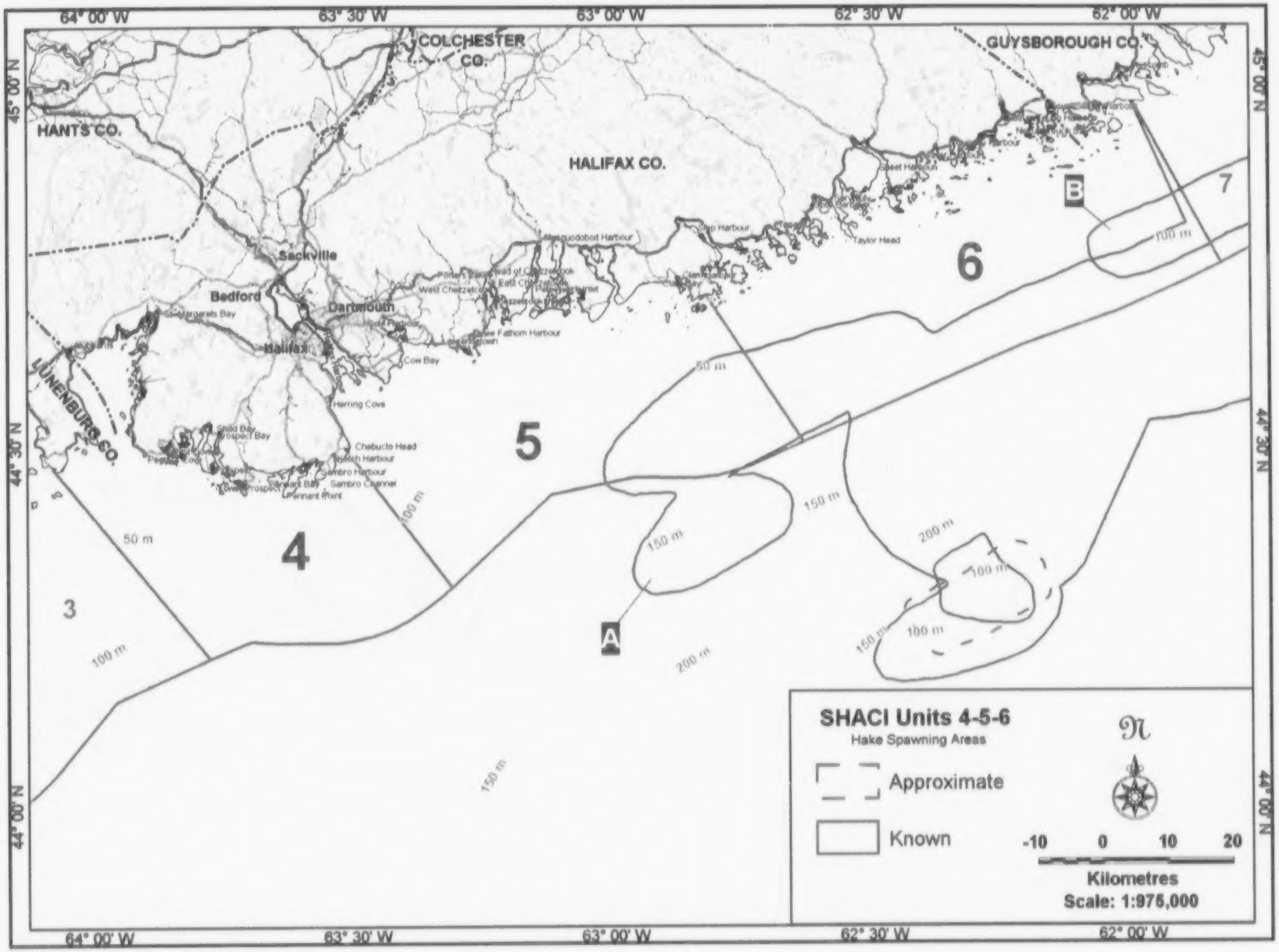


Figure 11-9: Hake spawning areas in SHACI Units 5 and 6 (based on data from Trippel 2002). Basemap layers (NSGC).

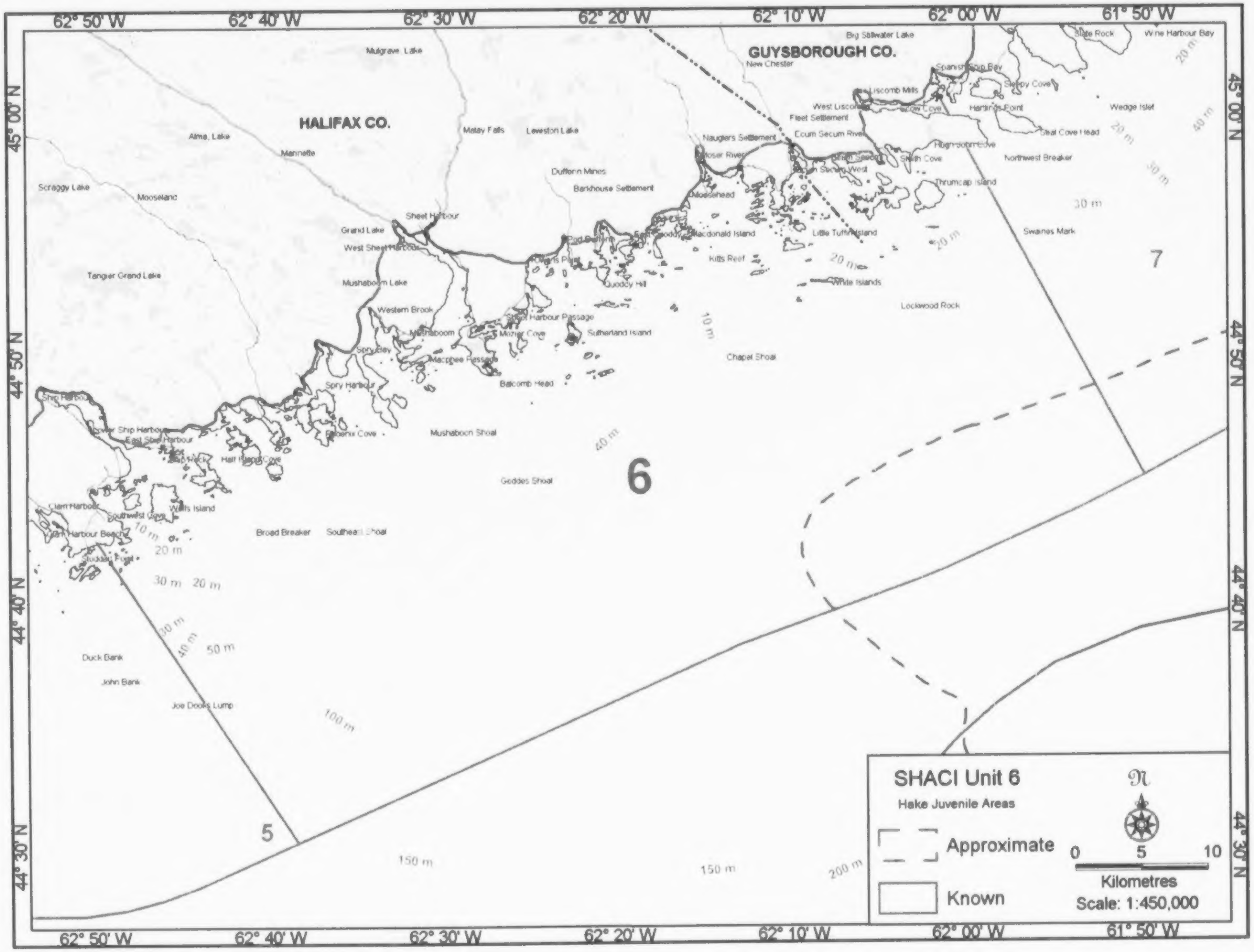


Figure 11-10: Hake juvenile areas in SHACI Unit 6 (based on data from Trippel 2002). Basemap layers (NSGC).

White hake

White hake (*Urophycis tenuis*) is a demersal fish that prefers temperatures from 5-11ºC (Scott and Scott 1988) and soft substrates of silt, mud and sand (Musick 1969 as cited by Archambault et al. 2001). White hake occupies different depths and habitats depending on its life history stage. The first two years are spent in shallow coastal waters after which white hake are found predominantly between depths of 50-200 m (DFO 2001b). The distribution of white hake also changes seasonally. During the spring, white hake concentrate in deep water along the shelf edge while in the summer they are found in shallower waters on the shelf (Bundy et al. 2001).

The stock structure of white hake in Nova Scotia waters is poorly understood and does not appear to conform to the boundaries of current management regions. White hake found in SHACI Units 4, 5 and 6 are part of the 4VWX and 5Zc management units. The condition of white hake stocks in this management unit are generally considered poor (DFO 2001b). There are likely exchanges between the white hake in 4X/5 and the US white hake stock in the Gulf of Maine and Georges Bank (Bundy et al 2001).

There are some known differences between white hake on the eastern and western Scotian Shelf. On the western Scotian Shelf, white hake are slightly larger than white hake on the eastern Scotian Shelf. There are also more large fish found on the western Scotian Shelf (Bundy et al. 2001).

Spawning areas

White hake spawn in the pelagic zone and the eggs and larvae drift in the upper 50 m for roughly one month. Larvae become juveniles in the pelagic zone, and then migrate to shallow coastal waters. They remain near the surface until two months of age when they move to bottom habitats. White hake stay in coastal areas for one year, and then migrate to the offshore adult distributional area (DFO 2001b).

Spawning locations and times for white hake on the Scotian Shelf are not well understood. Within the larger 4VWX and 5Zc management area there may be several self-sustaining spawning components. Parts of areas 4X and 4W on the central Scotian Shelf may be separate from those spawning to the east and the west. As well, there may be both a late spring/early summer and a late summer/early autumn spawning component (DFO 2001b).

According to TEK, hake spawning occurred in two areas of SHACI Units 5 and 6 (Figure 11-9) (Trippel 2002). The various comments associated with spawning area A are presented in Table 11-5. No comments were associated with spawning area B. Trippel's (2002) information does not distinguish between the different hake species found off the coast of Nova Scotia, therefore this reported site could be a silver or red hake (*Urophycis chuss*) spawning area.

Juvenile areas

The DFO Summer RV survey found that white hake were distributed differently depending on their size. In the spring and summer, small white hake were found more on the inner banks of area 4VsW, and adults were found further offshore. This research found no evidence of white hake nursery areas along the Atlantic coast (Bundy et al. 2001). Trippel (2002), however, reports a large hake juvenile area extending from off Necum Teuch to Canso on the eastern shore (Figure 11-10). This area has reportedly become smaller in size since the 1980s. This information, collected from TEK, does not distinguish between different species of hake.

Herring

Herring (*Clupea harengus*) are pelagic fish found all along the coast of SHACI Units 4, 5 and 6 (HCESCRMP 1996, HRMWRCRMP 1996), and are part of the 4VWX management unit. This area contains several spawning grounds, some of which are large and located offshore, and others that are small and more localized in coastal areas. For management purposes, the 4VWX unit is subdivided into different spawning components. Each spawning component has several spawning areas. SHACI Units 4-6 are considered part of the Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia Spawning Component (Power et al. 2004).

The seasonal cycle followed by herring in SHACI Units 4, 5 and 6 is as follows. Herring spawn in inshore areas during August and September. The larvae hatch by late September and early October and the young remain in the region until the following summer. After spawning, adult herring migrate great distances to feeding or overwintering areas where they mix with fish from other spawning components (DFO 2002a).

Spawning areas

Off Halifax County, herring spawn primarily during the fall in the shallow inshore waters of the bays and inlets located along the coast. Several surveys and reports have attempted to document spawning areas along the coast of Nova Scotia: Sameoto (1971), Crawford (1979), Clark et al. (1999), and Trippel (2002).

Within SHACI Units 4, 5 and 6, Sameoto (1971) reported spawning only during the fall (August-September) and generally occurring between the low tide line and in waters up to 20 fathoms (37 m). Based on the number of spawning beds reported and the extensive distribution of herring larvae along the coast, Sameoto (1971) concluded that this spawning group must contribute considerably to the Atlantic herring stock.

Clark et al. (1999) recorded more spawning locations than Crawford (1979) and Sameoto (1971), with the exception of the northern portion of Halifax County and the southern portion of Guysborough County. Areas including Brother and Tuffin Islands (Crawford 1979, Sameoto 1971), Phoenix Island and areas south of Liscomb Point may have been missed in the Clark et al. (1999) survey but recorded in earlier studies that sampled these areas more intensively (Clark et al. 1999). Clark et al. (1999) found herring spawning areas from Peggy's Cove to Owls Head Harbour. Clark et al. (1999) found that 21% of the historical herring spawning sites along the Atlantic coast of Nova Scotia were not active in 1998. They concluded that the difference was mainly due to the decrease in spring and summer fisheries, which was particularly noted by fishers in Halifax County.

The most recent information from Trippel (2002) indicates herring spawning areas from Peggy's Cove to Pennant Point, off Chebucto Head, and from Lawrencetown to Jeddore (Figure 11-11). No spawning locations are listed in the easternmost regions of Halifax County (Trippel 2002). Table 11-6 includes the comments collected by Trippel (2002) which are associated with each spawning area within SHACI study boundaries.

Table 11-6: Comments associated with herring spawning areas in SHACI Units 4 and 5 (Trippel 2002)

Map id	Approximate location	Associated comments
A	From Indian Harbour to Pennant Point	Inshore declined. 1985-1989.
B	Pennant Point to Herring Cove	-
C	Cole Harbour to Musquodoboit	1990-1994

Other information on herring spawning areas comes from DFO acoustic surveys conducted on the few known spawning grounds along the Atlantic coast of Nova Scotia. One spawning location surveyed regularly by DFO is located off Eastern Passage, and is generally referred to as 'East of Halifax'. Spawning stock biomass estimates based on October survey results from this area were estimated at 20 200 t of herring in 1999 (Stephenson et al. 2000), 10 865 t in 2000 (Melvin et al. 2001), 16 700 t in 2001 (DFO 2002a), 41 455 t in 2002 (Melvin et al. 2003) and 76 451 t in 2003 (Melvin et al. 2004).

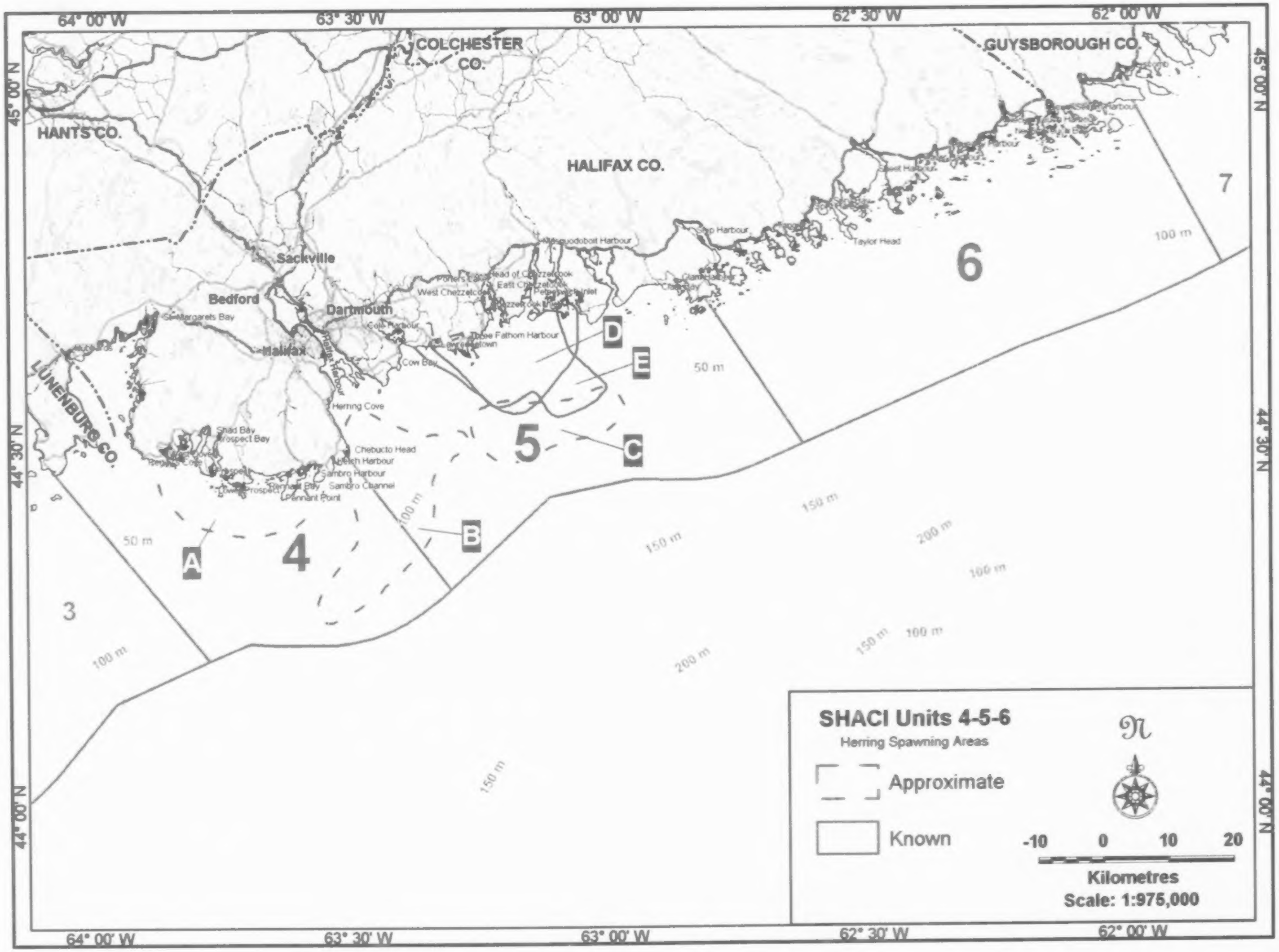


Figure 11-11: Herring spawning areas in SHACI Units 4 and 5 (based on data from Trippel 2002). Basemap layers (NSGC).

St. Margarets Bay

Sameoto's (1971) study closely examined a fall spawning population in the St. Margarets Bay region. Concentrations of herring larvae in this area increased in the late winter and early spring. Sameoto (1971) suggests that this influx of larvae was brought into the Bay by a water mass from some other area along the coast between Canso and St. Margarets Bay rather than from offshore areas. This conclusion was based on the results of larval sampling from a transect running perpendicular to the coast which seldom collected larvae in water deeper than 100 m.

Overwintering areas

Large schools of herring are known to aggregate off Chebucto Head in the winter. DFO acoustic surveys during January have recorded maximum biomass estimates of 482 956 t in 1999, 103 000 t in 2000 and 794 t in 2003 (Melvin et al. 1999, Melvin et al. 2001, Melvin et al. 2004). Results from a DFO tagging program initiated in 1998 confirm that there is an affinity between herring that overwinter off Chebucto Head and the Southwest Nova/Bay of Fundy spawning component (Waters et al. 2000). Although the majority of tags applied at the overwintering grounds of Chebucto Head between 1998 and 2003 were recaptured near the site of application, tags were also recovered along the southwest coast of Nova Scotia, on the offshore Scotian Shelf banks and southwest New Brunswick (Mouland et al. 2003).

Management concerns

Herring fishing is directed at dense summer feeding, overwintering and spawning aggregations. In recent years, knowledge of the fishery in the Coastal Nova Scotia Spawning Component has improved, however, biological and fishery information are still lacking. Spawning groups within this component are considered vulnerable to fishing because of their relatively small size and proximity to shore (DFO 2004). For this reason, in recent years DFO has recommended no effort increase for coastal spawning areas until information on the biomass and biological characteristics of the spawning groups become available. In addition, DFO recommends no new fisheries development for herring given the uncertainty about stock composition and the degree of mixing (DFO 2004).

Mackerel

Mackerel (*Scomber scombrus*) is present along the coast of SHACI Units 4, 5 and 6 (HCESCRMP 1996, HRMWRCRMP 1996) during several months of the year. They are a highly migratory species. After moving along the coast of New England in March/April, mackerel migrate along the Scotian Shelf and coastal areas of Nova Scotia on their way to the southern Gulf of St. Lawrence where they arrive in late May, June and early July (Grégoire et al. 2001). The majority of Atlantic mackerel spawn in the southern Gulf of St. Lawrence. After spawning, mackerel disperse to other areas in the St. Lawrence estuary and the Gulf of St. Lawrence, and occasionally the east coast of Newfoundland. Mackerel then leave the Gulf of St. Lawrence sometime between September and November (Grégoire et al. 2001).

Although the St. Lawrence is the major spawning area, the presence of mackerel eggs in spring samples taken from St. Margarets Bay indicates that some mackerel do spawn in coastal areas of Nova Scotia (Bernier and Lévesque 2000). Grégoire et al. (1999) found that in June, St.

Margarets Bay is visited first by adults who spawn and then by younger less mature individuals. It is uncertain whether the spawning adults remain in the area, or continue on to the Gulf of St. Lawrence.

Management concerns

The current abundance of mackerel in Canadian waters is considered low, and similar to that measured in the early 1980s. According to Grégoire et al. (2001), mackerel catch estimates for coastal Nova Scotia and the Maritimes in general are greatly underestimated since DFO catch statistics do not include data on the mackerel bait fishery or the summer recreational mackerel fishery. Without catch data from these fisheries, estimates of mackerel abundance may not accurately reflect the true status of the stock (Grégoire et al. 2001).

Swordfish

Swordfish (*Xiphias gladius*) are an incredibly wide ranging species. They are found in oceanic water with surface temperatures between 16°-21°C, and from the surface to great depths (Gibson 1998). Swordfish distribution is highly dependent on seasonal changes in water temperature. During the winter in the Atlantic, swordfish are found in Gulf Stream waters where surface temperatures exceed 18°C (Beckett 1974). During the summer, the warm Gulf Stream waters move further north and inland over the Scotian Shelf, allowing swordfish a wider distribution into more northern areas of the Atlantic. On the fishing banks off the coasts of Nova Scotia and Newfoundland, this warm Gulf water mixes with cold Arctic water, concentrating nutrients and creating an abundance of food for swordfish and other species (Fitzgerald 2000).

Local distributional information for swordfish comes mainly from landings data. Figure 11-12 illustrates that swordfish are caught in SHACI Units 4-6, however, the majority of catches occur in deeper waters. Local coastal resources mapping information also records the presence of swordfish in coastal waters off Halifax County (HCESCRMP 1996, HRMWRCRMP 1996).

Bluefin tuna

Bluefin tuna (*Thunnus thynnus*) are wide ranging, large pelagic fish that enter Canadian waters in June and remain until December. The distribution of bluefin tuna in Atlantic Canadian waters is often unpredictable. Any information on bluefin tuna distribution comes solely from commercial fisheries data (Archambault et al. 2001). The DFO landings data indicate that bluefin tuna are caught in SHACI Units 4, 5 and 6 (Figure 11-13).

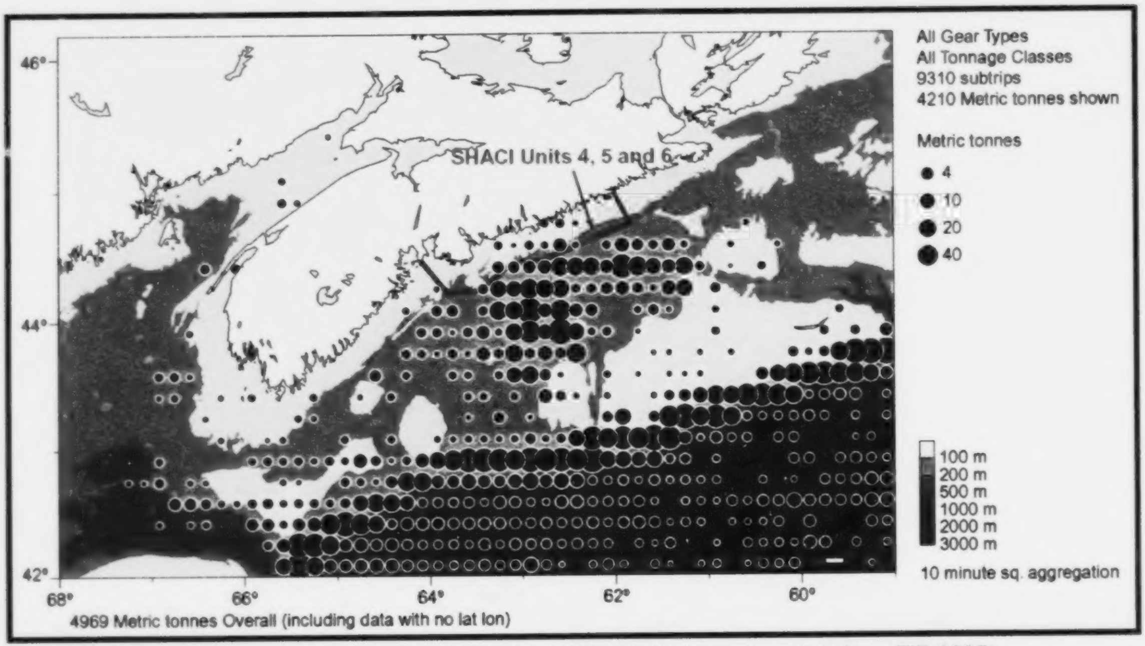


Figure 11-12: Swordfish landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

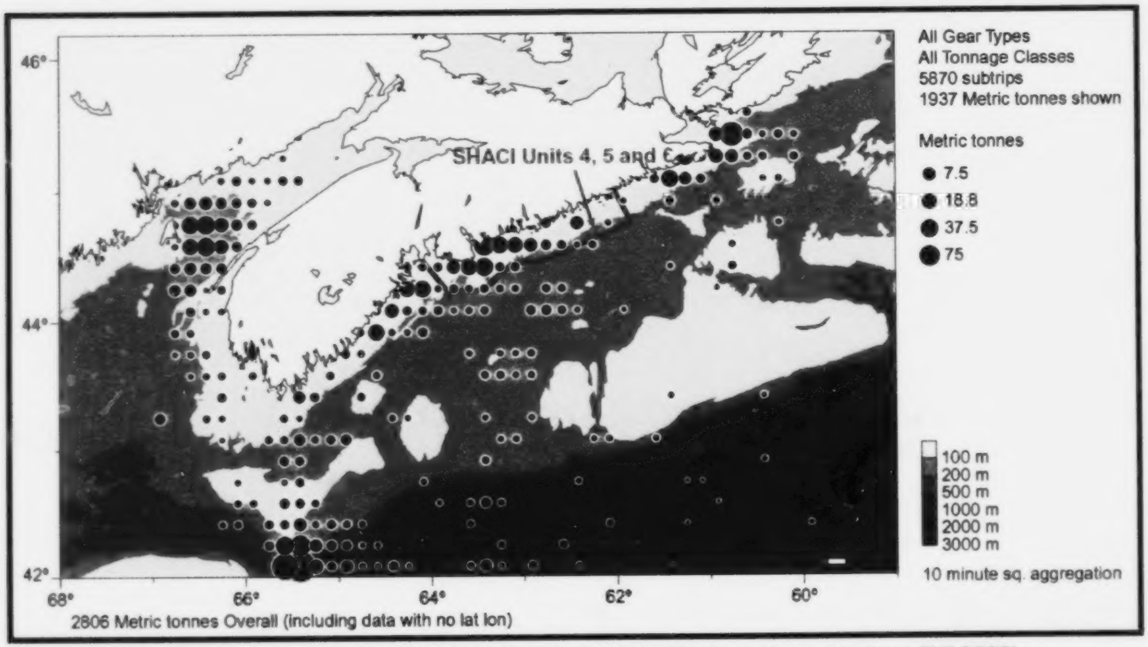


Figure 11-13: Bluefin tuna landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005). St. Margarets Bay trap catches are not shown.

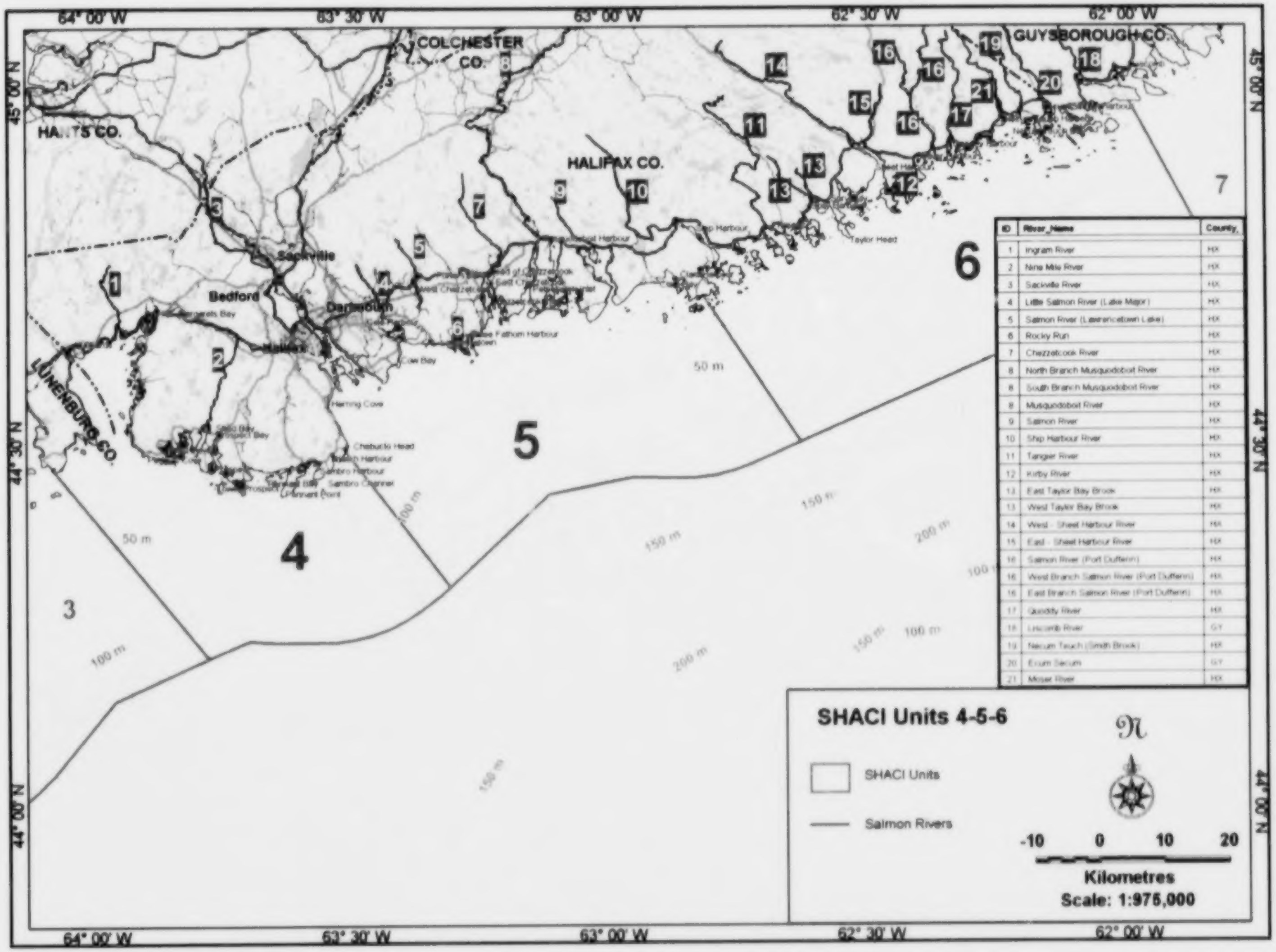
Diadromous species

Both anadromous and catadromous fish species are found in the rivers and estuarine areas of SHACI Units 4, 5 and 6; these include striped bass, gaspereau (alewife and blue back herring), shad, smelt, trout, eel, tomcod, perch and Atlantic salmon (HCESCRMP 1996, HRMWRCRMP 1996).

Atlantic salmon

Atlantic salmon (*Salmo salar*) are found in rivers along the coast of SHACI Units 4, 5 and 6. Any river that is not intermittent and is circumneutral in pH is potential habitat for Atlantic salmon. A good indication of the occurrence of salmon in rivers is the presence of salmon angling. Rivers with reported salmon angling in SHACI Units 4, 5 and 6 are shown in (Figure 11-14) (O'Neil et al. 1996). Unfortunately, salmon stocks in this area have declined in recent years due to water quality (i.e., acidification) issues and high mortality at sea.

In spawning salmon populations there are varying proportions of small (<63 cm) and large (≥ 63 cm) fish. In most rivers, the small salmon (called grilse) have spent one year at sea and have never before spawned. The large salmon include both previous spawners and first time spawners that have spent two or more years at sea and are called multi-sea winter fish (DFO 2002b).



ID	River_Name	County
1	Ingram River	HX
2	Nine Mile River	HX
3	Sackville River	HX
4	Little Salmon River (Lake Major)	HX
5	Salmon River (Lawrencetown Lake)	HX
6	Rocky Run	HX
7	Chezzetcook River	HX
8	North Branch Musquodoboit River	HX
8	South Branch Musquodoboit River	HX
8	Musquodoboit River	HX
9	Salmon River	HX
10	Ship Harbour River	HX
11	Tangier River	HX
12	Kirby River	HX
13	East Taylor Bay Brook	HX
13	West Taylor Bay Brook	HX
14	West - Sheet Harbour River	HX
15	East - Sheet Harbour River	HX
16	Salmon River (Port Dufferin)	HX
16	West Branch Salmon River (Port Dufferin)	HX
16	East Branch Salmon River (Port Dufferin)	HX
17	Quoddy River	HX
18	Liscomb River	GY
19	Necum Teuch (Smith Brook)	HX
20	Ecum Secum	GY
21	Moser River	HX

Figure 11-14: Salmon rivers in SHACI Units 4, 5 and 6 (based on data from O'Neil 1996). Basemap layers (NSGC).

Salmon found east of Halifax are summer-run stock that enter rivers typically between April and July but can enter rivers until the end of September (DFO 1998b). Those that return in the spring but do not ascend rivers until the fall appear to remain locally in estuaries along the coast. The timing of ascent up-river may be influenced by inherited differences in physiology and behaviour but is mostly affected by water temperature and levels. The different residence times of salmon in estuaries have important implications when estimating the effect of estuarine toxics and pollutants on salmon (Brawn 1982).

Salmon management

Atlantic salmon populations in the Maritimes are managed within different Salmon Fishing Areas (SFAs). Salmon rivers found in Halifax County are part of SFA 20, which extends from the eastern end of Halifax Harbour to the Strait of Canso, and SFA 21 which extends from the western end of Halifax Harbour and around southwest Nova Scotia to Digby (DFO 1998c) (Figure 11-15).

The status of rivers with different levels of acidity is assessed by DFO in SFA 20 and 21 by closely examining certain index rivers. Rivers with pH levels >5.1 are considered low or non-acidified, those with pH levels from 4.7-5.0 are partially acidified and those with a pH level <4.7 are considered heavily acidified. Salmon production is unstable and only remnant populations may remain at pH levels lower than 5.1 (DFO 2002b).

To manage salmon populations, DFO defines conservation requirements for the various salmon stocks and rivers. For Atlantic salmon, the "conservation requirement" is a threshold reference point. Conservation requirements are defined as the number of spawner eggs required to seed the habitat at a rate of 2.4 eggs/m^2. Although the exact consequences of egg depositions below the reference point are unknown, the likelihood of deleterious effects is greater when egg depositions are below the conservation requirements (DFO 2002b). The nominal conservation requirements for rivers in SFA 20 have been estimated based on habitat area but river-specific levels have not been defined for many rivers in the area, because the effect of acidity levels by habitat area is not well known (DFO 1998b).

Historical salmon management practices also involved stocking rivers with hatchery reared fish. Within Halifax County, the East River Sheet Harbour, Liscomb, and the Musquodoboit rivers were stocked with young salmon in the 1990s. Research indicates that these hatchery fish do return to spawn in the rivers where they were released. Mitigation of acidification by liming headwater lakes or streams has been employed on a trial basis on several acid-impacted rivers. Some user groups in SFA 20 view this practice as the only means of maintaining salmon in acid-stressed rivers (DFO 1998b).

Commercial fisheries for Atlantic salmon were operated along the coast of Nova Scotia until after the 1984 season when they were closed due to low abundance of salmon. Fishing gear was typically set in areas where local runs existed or migration paths were known. Catches in the late 1970s in SHACI Units 4, 5 and 6 ranged from 7000-31 000 kg (Dunfield 1977, Mitham and Bernard 1978 & 1979, Smith and Bernard 1980). In the late 1970s and 1980s, large amounts of Atlantic salmon (15 203 kg-48 000 kg/year) were taken as bycatch in other coastal fisheries in Nova Scotia. In many cases, it was suspected that fishermen were deliberately catching salmon under the auspices of catching cod or some other species. Roughly 73% of this bycatch was taken from five locations, four of which are located within SHACI Units 4, 5 and 6: Herring Cove-Pennant, St. Margarets Bay-Mahone Bay, Little Harbour, and Ecum Secum (Gray et al. 1980). Collectively these data indicate the importance of the coastal habitats for salmon in this area.

Salmon bycatch became illegal in the early 1980s. Commercial fishers for salmon were required to tag fish beginning in 1983. Recreational catch tags were issued in the same year. Salmon captured as bycatch had to be released, dead or alive. Anyone in possession of an untagged salmon could be charged (O'Neil pers. comm. 2002). Those regulation changes led to a decline in bycatch but also a limited ability to obtain reliable bycatch information (O'Neil *et. al.* 1985). It is generally assumed that bycatch is no longer the issue that it once was (Marshall pers. comm. 2002).

Salmon habitat

Rivers along the Atlantic coast of Nova Scotia are typically organic-acid stained, naturally acidic and have relatively low productivity. These characteristics, when combined with acid precipitation, can result in acidic conditions that are toxic to salmon. There are some drainage areas, however, with limestone rich soils that buffer the acidity and result in localized areas of less acidified waters (DFO 2002b).

Rivers in SHACI Units 4, 5 and 6 have a range of acidities (Table 11-7). Many are acid-stressed, and their capacity to support salmon populations is limited. The pH is too low for salmon production in four of the area's rivers: Cole Harbour, Larrys, Lawrencetown Lake and Salmon (Halifax County). Within SHACI Units 5 and 6, only two rivers have pH levels suitable for Atlantic salmon production: Moser and Musquodoboit (O'Neil et al. 1998).

Based on 2001 assessments of status and performance of salmon stocks in index rivers, salmon populations in all rivers along the Atlantic coast of Nova Scotia were deemed insufficient to meet conservation requirements (DFO 2002b), and have retained that status into 2005 (O'Neil pers. comm. 2005).

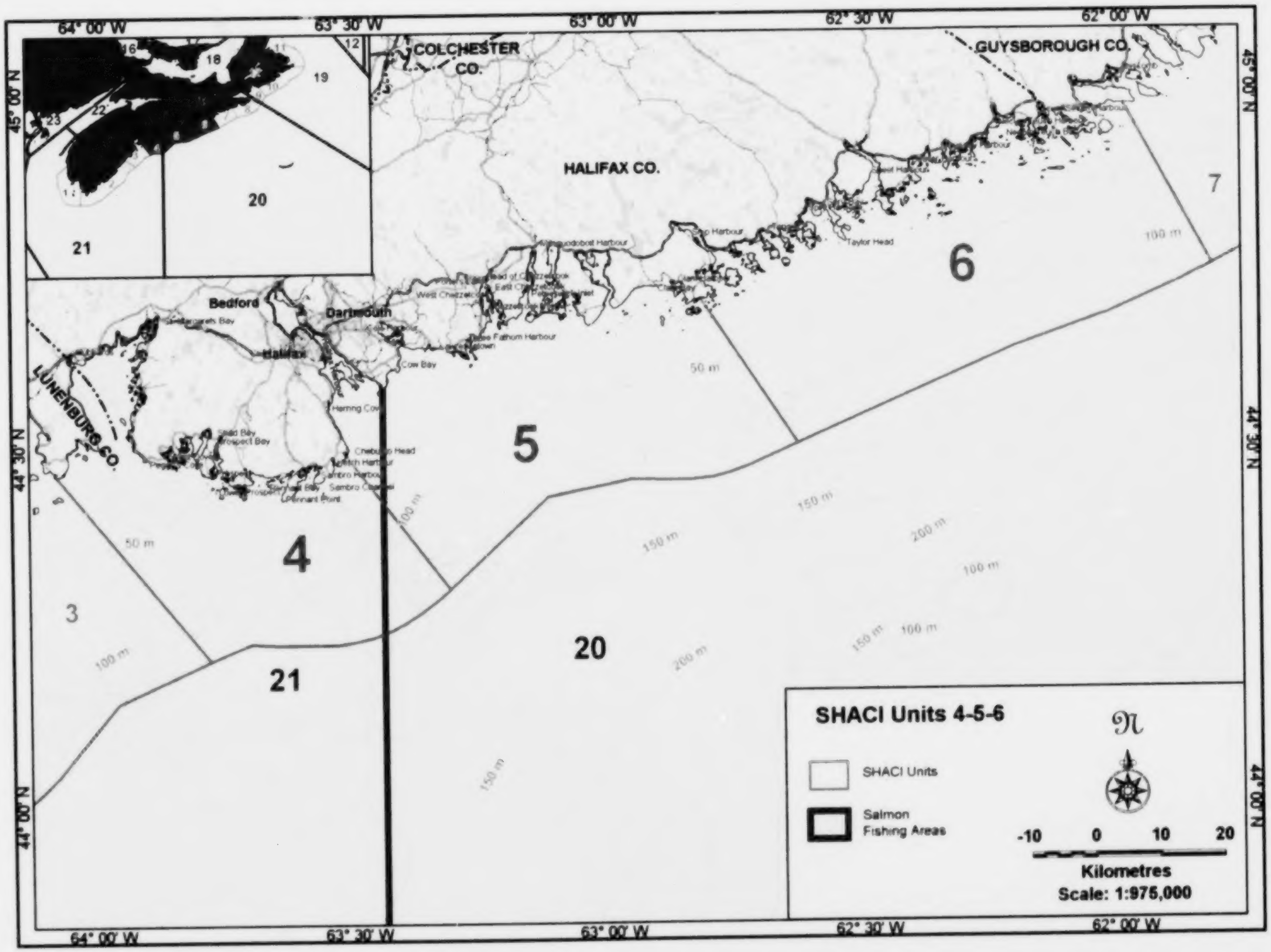


Figure 11-15: Salmon fishing areas (SFAs) 20 and 21 (DFO). Basemap layers (NSGC).

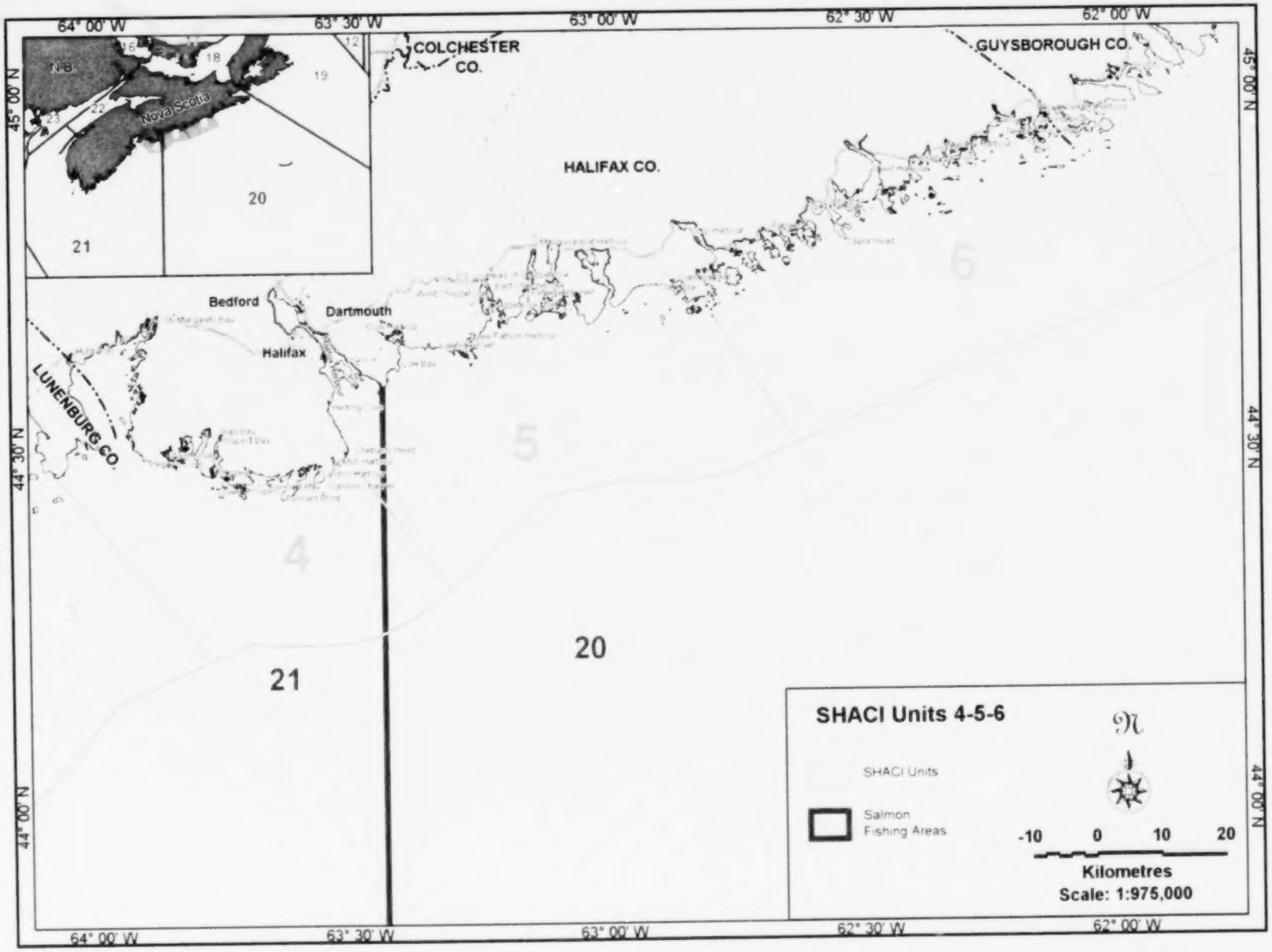


Figure 11-15: Salmon fishing areas (SFAs) 20 and 21 (DFO). Basemap layers (NSGC).

Musquodoboit River

The Musquodoboit River is one of the few rivers in SHACI Units 4, 5 and 6 which is not seriously affected by acidity. Hence, this river yields a large proportion of the salmon angled in Halifax County (DFO 1998b). The roughly 95 km long Musquodoboit watershed drains an area underlain with limestone deposits and thus has a buffering capacity high enough to maintain a pH level over 5.5 (O'Neil et al. 1998). A more detailed description of the Musquodoboit River system is provided by O'Neil et al. (1997). Salmon from non-acid-impacted rivers, like the Musquodoboit, are still subject to low marine survival rates (O'Neil et al. 1998).

Musquodoboit River salmon are among the earliest to spawn in Nova Scotia. Spawning typically begins in mid to late October. The Musquodoboit River salmon stock consists of 40% large and 60% small salmon, however, 92% of the egg requirement is expected to come from large fish. During years when the river was being stocked with hatchery salmon, they contributed 42% of the small and 18% of the large salmon spawners in this river (DFO 1998b).

In SFA 20 and 21, small and large salmon have historically contributed equally to egg deposition (DFO 2002b). In most eastern shore rivers, however, the spawning requirement in eggs comes largely (~95%) from small salmon (DFO 1998b). Large salmon have roughly 1.5 times more eggs per fish than do small salmon (DFO 1998c).

Table 11-7: The pH and habitat area of Atlantic salmon rivers in SHACI Units 5 and 6 (SFA 20, Eastern Shore) arranged in pH category from Watt (1986) (O'Neil et al. 1998)

pH	River	Habitat area $m^2 * 10^2$
< 4.7	Salmon (Halifax County)	2811
	Lawrencetown Lake	6446
	Cole Harbour	1244
	Larry's	2410
4.7 – 5.0	Porter's Lake (East Brook)	2332
	Tangier	13 583
	Isaac's Harbour	2043
	New Harbour	3148
	Clam Harbour	2736
	Liscomb	16 856
	Little Salmon	750
5.1 – 5.4	Gaspereau Brook	2823
	West Sheet Harbour	3700
	East Sheet Harbour	29 749
	Port Dufferin	5389
	Halfway Brook	1604
> 5.4	Ecum Secum	7663
	Quoddy	6849
	Moser	15 208
	Ship Harbour Lake Charlotte	19 615
	Musquodoboit	7919

East River Sheet Harbour

The East River, Sheet Harbour, is used as an index river for partially acidified rivers. Much of the habitat (95%) in this river is largely inaccessible to anadromous fish because it lies above an impassable hydroelectric dam built in the 1920s (O'Neil et al. 1998). There is no conservation requirement in place for this river since the dam construction destroyed the salmon resource. Salmon only continued to exist in this river because it was stocked with salmon from federal fish hatcheries. Despite stocking efforts, salmon counts in this river were low from 1998-2001. The high acidity (i.e., low pH) may cause a high rate of mortality in stocked smolts (DFO 2002b).

Liscomb River

The Liscomb River is considered acid-stressed. This river drains an area of 400 km^2, and several of its tributaries also cannot support salmon due to acidity levels (O'Neil et al. 1998). O'Neil et al. (1997) describe nominal conservation requirements for the Liscomb River.

West River Sheet Harbour

The West River, Sheet Harbour, is considered acid-stressed and returns to this river are critically low (DFO 1998b). One tributary of the river, the Little West, has a pH level of 5.2 so is less acid-stressed than much of the watershed. One tool to mitigate the acidity that has been employed in the West River is the spreading of limestone gravel. In an attempt to protect the remaining salmon, angling has been closed on this river since 1993 (O'Neil et al. 1998).

Gaspereau

Alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) are two species of clupeid fish known collectively as gaspereau. Gaspereau are anadromous fish that migrate up Maritime rivers to spawn in the late spring and return to the sea soon thereafter. Alewife is predominant over blueback herring in most rivers along the Atlantic Coast of Nova Scotia (DFO 2001c). Within SHACI Units 4, 5 and 6, blueback herring are known to occur in the Ship Harbour River (Stone et al. 1992).

There is relatively little biological information available about the gaspereau that inhabit many of the rivers along the Atlantic coast of Nova Scotia (Stone et al. 1992). Gaspereau are known to return to the rivers where they were spawned but will also colonize new streams or ponds and recolonize areas from which they had been extirpated (Loesch 1987). Alewives' spawning migrations typically begin in late April to early May, peak in late May or early June and are completed by late June or early July (DFO 2001c). The blueback herring spawning migration usually begins roughly two weeks later than alewife (DFO 2001c).

According to Stone et al. (1992), nearshore marine temperatures may influence the timing and arrival of gaspereau into an estuary. Along the eastern shore of Nova Scotia, cold sea temperatures in the spring may delay the migration of fish from coastal waters into the estuaries.

Gaspereau habitat

Where the species co-occur, blueback herring tend to spawn in fast-flowing streams with associated hard substrate (Loesch and Lund 1977), while alewives spawn in slow-flowing areas of streams or enter ponds and lakes (Loesch 1987). Juvenile young-of-the-year gaspereau spend their first summer and may spend fall in fresh water before migrating to sea (DFO 2001c).

The freshwater life history of gaspereau is well known (Loesch 1987) but little information is available on the distribution and movements of gaspereau at sea, particularly in Canadian coastal waters (Stone and Jessop 1992). Gaspereau seem to move offshore in the winter and inshore in the summer. This change in temporal and spatial distribution is greatly influenced by oceanographic features including temperature and shifts in zooplankton abundance (Stone and Jessop 1992).

Gaspereau found in SHACI Units 4, 5 and 6 rivers likely overwinter along the southwestern Scotian Shelf. This is indicated by the high concentrations of gaspereau found offshore in the deeper warm water areas of the southwestern Scotian Shelf and Bay of Fundy in the spring, and their rarity at this time on the eastern Scotian Shelf and in inshore waters (Stone and Jessop 1992).

American eel

Eels are catadromous species; they breed in marine waters and return to freshwater early in their development where they remain for 5-15 years until they return to sea to spawn (Hutchinson and Taylor 1980, Scott and Scott 1988). During the freshwater phase in their life cycle, eels live in streams, rivers and silt-bottomed lakes. Eels are active during the summer but become sluggish as the water cools; they overwinter in the muddy bottoms of lakes and rivers (Scott and Scott 1988).

Eels have a true larval stage called a leptocephalus. These larvae migrate from the eel spawning area in the Sargasso Sea and transform from the leptocephalus stage into a small transparent eel (glass eels) during the winter when approaching inshore waters. Glass eels typically enter Canadian estuaries in April. Once in estuaries, the glass eels develop pigmentation and become almost black in colour. Now called elvers, the eels enter rivers in May and June (Scott and Scott 1988), or roughly when the water temperature reaches 8°-10°C (Hutchinson and Taylor 1980). Some elvers move upstream into freshwater lakes, while others remain in estuaries and coastal waters (Hutchinson and Taylor 1980). During the 5-15 year period in which eels inhabit coastal waters, they metamorphose into adult yellow eels, and then again into silver eels before they descend rivers in their seaward migration. The timing of the silver eel run is influenced by the lunar cycle; in Nova Scotia, the main run begins with the first new moon in September. Eels are caught commercially at this time (Hutchinson and Taylor 1980).

American eels (*Anguilla rostrata*) are found in the estuaries and rivers of SHACI Units 4, 5 and 6 (HCESCRMP 1996, HRMWRCRMP 1996). There is little current biological information about American eels found in rivers and estuaries along the Atlantic coast of Nova Scotia (Jessop 1996). At sea, larval eels are planktivores but in freshwater, both juvenile and adult eels are carnivorous. They feed mainly at night on a wide variety of fish and invertebrates. Larval eels and elvers are likely prey for a number of species including haddock (Needler 1929) and Black-backed Gulls (Seymour 1974).

Hutchinson (1982) assessed the eel population in Nova Scotia. Results compared different regions of the province and found that eel populations along the Atlantic coast of Nova Scotia (the Southwest Shore, South Shore and Eastern Shore) are comprised of smaller and older individuals compared to eel populations on the North Shore. Waters along the Atlantic coast were also considerably more acidic. Hutchinson (1982) suggests that low pH levels may result in decreased food sources for the eel since its prey is negatively affected by low levels of pH.

American shad

American shad (*Alosa sapidissima*), an anadromous species, lives at sea and enters freshwater in spring to spawn. Shad is highly migratory and forms large schools. At sea, American shad are found in discrete aggregations and at widely separated geographical locations. These aggregations are made up of a heterogeneous mixture of American shad from many different coastal rivers. An American shad may migrate over 20 000 km during an average five year lifespan at sea (Dadswell et al. 1987).

Shad from Canadian waters migrate southward in the fall (October or November) to overwinter off the mid-Atlantic states (Cheek 1968) or in the Scotian Shelf-Gulf of Maine region (Dadswell et al. 1987). In the spring, both spawning adults and non-spawning younger fish migrate northward in the direction of the rivers in which they were spawned (Legett 1973, 1976). Ripe, prespawning adults select ocean isotherms of 13-18°C and migrate through coastal waters within a few kilometres of shore. This migration route is possibly used to facilitate the recognition of homing clues to native rivers (Dodson and Dohse 1984). Non-spawning shad migrate offshore in ocean isotherms ranging from 3-15°C (Neves and Depres 1979).

In Canadian waters, spawning occurs in May, June or even July when water temperatures reach between 16.5 and 19°C. Shad home to their natal stream (Dodson and Legett 1973, 1974; Carscardden and Leggett 1975; Melvin et al. 1986). Spawning occurs at night and peak spawning occurs at temperatures of roughly 18°C, and often in brackish waters (Leim 1924 as cited by Scott and Scott 1988). Shad are repeat spawners and may return to the same river to spawn up to five times (Carscardden and Leggett 1975). Young shad move downstream into brackish waters and then enter marine waters once they have grown to between 50-70 mm long. They remain and mature in marine waters, joining schools with larger, older shad (Scott and Scott 1988).

Shad are opportunistic planktivores, eating copepods, mysids, other crustacean zooplankton, and aquatic insect larvae. Small fish including smelt and sand lance constitute a small part of the shad diet (Scott and Scott 1988). Other than seals and monkfish caught in weirs, shad have few predators besides humans (Scott and Scott 1988).

Rainbow smelt

Rainbow smelt (*Osmerus mordax*) have anadromous and land-locked forms. The land-locked form is found in several freshwater lakes in Nova Scotia but has not been well documented. The anadromous form lives in coastal waters and ascends rivers in the spring to spawn. A schooling species, smelt are often seen in large numbers in estuaries and rivers during spawning migrations. They are thought to be limited in their coastal migrations and to home to their natal rivers (Jessop 1993). In the summer, smelts move to deeper, cooler waters offshore (Bigelow and Schroeder 1953). In the fall and late winter months, smelt move into estuaries to avoid cold waters. They are distributed in suitable bays and estuaries along the Atlantic coast of North America from Labrador to New Jersey (Scott and Scott 1988).

During the spring, spawning typically takes place at night in streams in freshwater areas above the head of tide. Spawning will occur below the head of tide if stream obstructions bar access to upstream areas. Smelt eggs are small, spherical and adhesive. They sink to the bottom and attach to substrate, vegetation and each other. Incubation time varies from 8-63 days depending on water temperature. Once hatched, the smelt fry are carried downstream to brackish water (Scott and Scott 1988).

There is no recent biological data available for smelt stocks in Nova Scotia waters. The available information is limited to license numbers and reported landings by Fisheries Statistical Districts (Jessop 1993).

Management issues

Rainbow smelt in SHACI Units 4, 5 and 6 are affected by barriers such as mill dams and culverts that obstruct their access to spawning areas. Smelts are unable to ascend vertical drops exceeding 15-20 cm. The acidification of rivers by acid rain likely also has deleterious effects on rainbow smelt (Jessop 1993). Long exposure of smelt eggs to pH levels of 4.5 and 5.5 decreases survival (Geffen 1990).

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12 - Marine associated birds

A wide variety of seabirds, shorebirds and waterfowl use the rocky inshore islands, sheltered salt marshes, intertidal flats and sandy beaches of SHACI Units 4-6 throughout the year. Several of these species are present only to breed during the summer months (May to September) but many others visit during the spring and especially fall migrations (P. Lane and Associates 1992), or occur over winter. Breeding colonies are scattered across Units 4-6, with a few well-recognized concentrations between Halifax and Clam Bay.

Seabirds

Lock et al. (1994) of Environment Canada's Canadian Wildlife Service (CWS) considered seabird habitat along Maritime province coasts while developing an atlas of seabird vulnerability to oil pollution. They found that the shores of SHACI Units 4-6 exhibited medium seabird density during all months of the year except June to September, when seabird density was high for the entire Nova Scotian Atlantic coast south of Scataric Island. These findings are based on fragmentary data, and the breeding locations of many species within Halifax Regional Municipality (HRM) coastal waters, although widely distributed, are often undocumented. There are large gaps in CWS' knowledge of both summer and winter seabird distributions off HRM.

Several seabird species breed in the coastal areas of HRM (Table 12-1). There are known breeding colonies of three types of auks (Atlantic Puffin, Razorbill and Black Guillemot) as well as Leach's Storm-Petrel, although none are large. Of these, the Black Guillemot exists in the greatest numbers, and its breeding colonies, distributed around the coast, are mostly undocumented (Lock et al. 1994). All four species breed on Pearl Island but their numbers here are smaller than those found in Sydney Bight and elsewhere among the Atlantic provinces. The breeding populations of the Atlantic Puffin, also found among the Eastern Shore Islands of Unit 6, are growing with new, small colonies appearing recently in the province (Chardine 1999). There are few records of Leach's Storm-Petrel colonies besides those included in the Halifax County Eastern Shore Coastal Resource Mapping Project (HCESCRMP 1996). This project used traditional ecological knowledge to document these colonies at Clam Bay and several locations within the Eastern Shore Islands Wildlife Management Area (ESIWMA), including Pumpkin, Brother, Horse, Harbour, Bird, Long, Big Halibut and White Islands. Populations of the Leach's Storm-Petrel, while doing well in its primary breeding grounds of Newfoundland and Labrador, appear to be decreasing locally (Chardine et al.1999). Leach's Storm-Petrel populations are particularly difficult to estimate for several reasons: they breed exclusively in underground burrows on uninhabited offshore islands, and enter and leave these burrows only under cover of darkness (Erskine 1992).

Seabird colonies are usually located on offshore islands or isolated coastal areas offering protection from potential predators (Tables 12-2a to 12-2h, Figures 12-1a to 12-1h). The specific breeding requirements of seabirds, including nesting habitats, local food sources and minimal disturbances, puts suitable sites in sometimes scarce supply. Some species, despite finding ample breeding sites, are decreasing due to other factors. Arctic Terns and Roseate Terns, for example, nest in several small colonies along the coast, and their numbers have decreased in recent decades, locally and across the Atlantic region, due to disturbance and gull predation (Lock et al. 1994, Chardine et al. 1999).

Table 12-1: Seabirds breeding in SHACI Units 4-6

Species*	Population trend in Canada**	Location of colonies***	
Pelagic seabirds			
Atlantic Puffin *Fratecula arcica*	Increasing	Pearl Island	
Razorbill *Alca torda*	Increasing	• Pearl Island	
Black Guillemot *Cepphus grylle*	Unknown	• Pearl Island • Bird (Halibut) Islands	
Leach's Storm-Petrel *Oceanodroma leucorhoa*	Unknown	• Pearl Island • Eastern Shore Islands	
Neritic seabirds			
Herring Gull *Larus argentatus*	Decreasing	• Cole Harbour • Pearl Island • All over coast, specific sites unidentified	
Great Black-backed Gull *Larus marinus*	Decreasing	• Cole Harbour • Pearl Island	
Double-crested Cormorant *Phalacrocorax auritus*	Increasing	• Tobacco Island • Little Halibut Island • Middle Halibut Island • Gull Rock • Goose Island • Long Island • Bowen's Ledge • Speck Island • The Pancake • Green Island	• Leslie Island • Mushaboom Hbr, unidentified Island • The Brothers • Outer Island • Bale Island • Long Island • Jeddore Rock • Shut In Island • Mackerel Island
Great Cormorant *Phalacrocorax carbo*	Unknown	• Big Brother Island • Pearl Island	
Roseate Tern *Sterna dougallii*	Declining	• Fisherman's Beach • Sambro Island • Western Bird Island	• Wedge Island • Macdonald's Point
Arctic Tern (*Sterna paradisaea*)	Declining	• Pearl Island	
Common Tern (*Sterna hirundo*)	Stable	• Pearl Island	

Lock et al. (1994), Maybank (1995), BSC (2002), Environment Canada (2002a & b)

** Chardine et al. (1999), Downes et al (2002)

*** Tufts (1986), P. Lane and Associates (1992), Lock et al. (1994), BSC (2002), Environment Canada (2002a)

Environment Canada (2003c)

Table 12-2a: SHACI Unit 4a seabird colonies

Map order ID	Colony name	English name summary
1	Gravel Island	Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull
2	Southwest Island (NS)	Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull
3	Horse Island, St. Margarets Bay	Cormorant spp.
4	Wood Island, St. Margarets Bay	Great Black-backed Gull
5	Sheep Island, St. Margarets Bay	Herring Gull
6	Wedge Island	Arctic Tern, Cormorant spp., Common Tern, Great Black-backed Gull, Herring Gull, Roseate Tern, Common/Arctic Tern
7	Neil's Island	Common/Arctic Tern
8	Franks George Island	Great Blue Heron
9	Lukes Island	Herring Gull
10	Dover Island	Great Black-backed Gull
11	Taylor Island Group	Herring Gull
12	Simmons Island	Great Black-backed Gull
13	Flemming Island	Great Black-backed Gull
14	Dover Castle	Great Black-backed Gull
15	Gull Island, Outer	Cormorant spp., Great Black-backed Gull
16	Gull Island, Inner	Cormorant spp., Great Black-backed Gull, Herring Gull

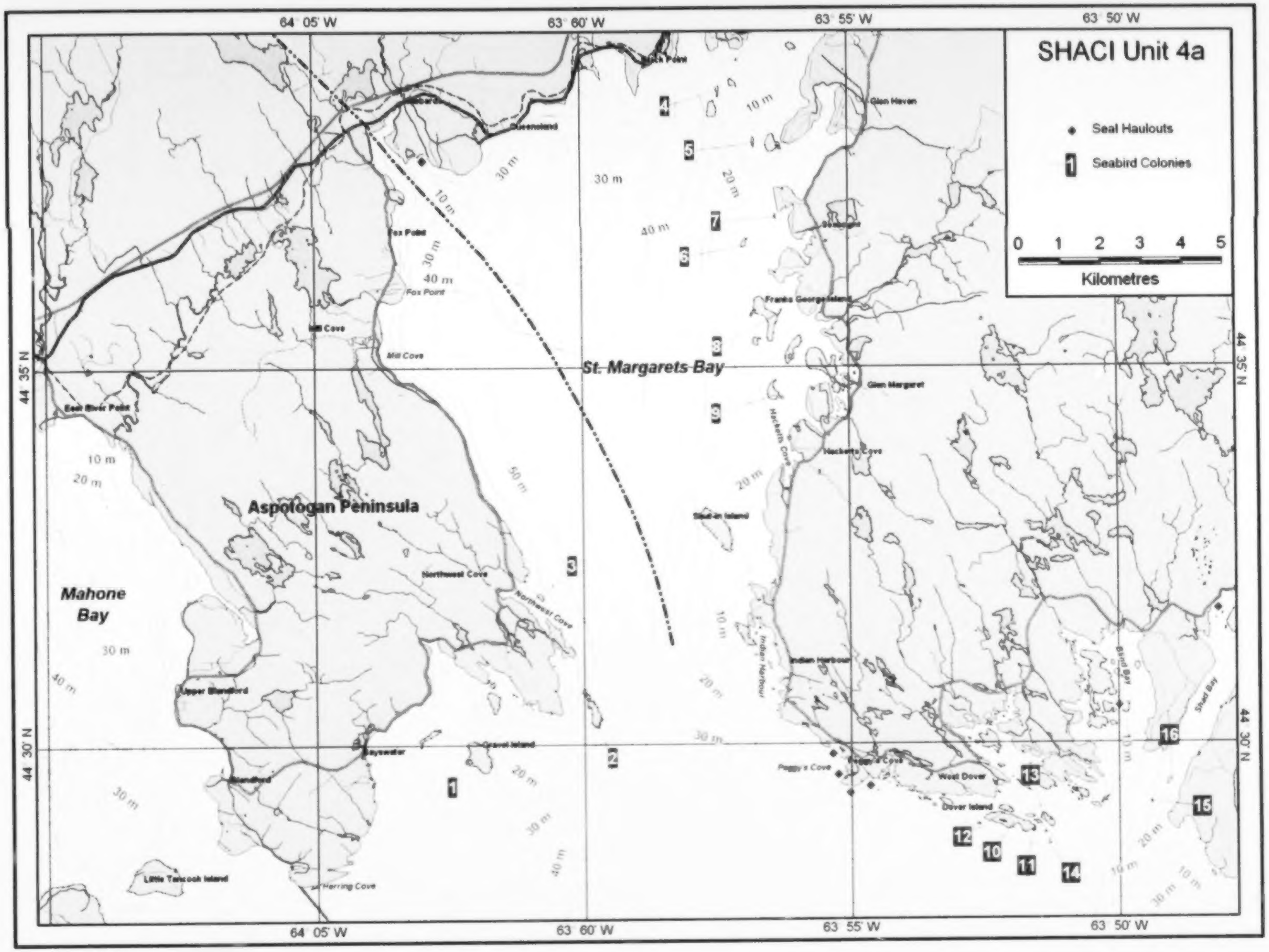

Figure 12-1a: Locations of seabird colonies and seal haulouts in SHACI Unit 4a (based on data from HRMWRCRMP 1996 and Environment Canada Seabird Colonies database 2002). Basemap layers (NRCan).

Table 12-2b: SHACI Unit 4b seabird colony

Map order ID	Colony name	English name summary
10	Dover Island	Great Black-backed Gull
11	Taylor Island Group	Herring Gull
12	Simmons Island	Great Black-backed Gull
13	Flemming Island	Great Black-backed Gull
14	Dover Castle	Great Black-backed Gull
15	Gull Island, Outer	Cormorant spp., Great Black-backed Gull
16	Gull Island, Inner	Cormorant spp., Great Black-backed Gull, Herring Gull
17	Hopson Island	Great Black-backed Gull, Herring Gull
18	Duck Island (PB)	Great Black-backed Gull, Herring Gull
19	Betty Island	Common Tern, Great Black-backed Gull, Great Blue Heron
20	Lower Woody Island	Great Black-backed Gull
21	Woody Island	Great Black-backed Gull, Herring Gull
22	Mackerel Island	Cormorant spp., Double-crested Cormorant
23	Powers Island	Great Black-backed Gull, Great Blue Heron
24	Saddle Island	Great Black-backed Gull, Herring Gull
25	Martin Island	Great Black-backed Gull, Herring Gull
26	Thrumcap	Cormorant spp., Great Black-backed Gull
27	Sambro Island, Inner	Great Black-backed Gull, Herring Gull, Common/Arctic Tern

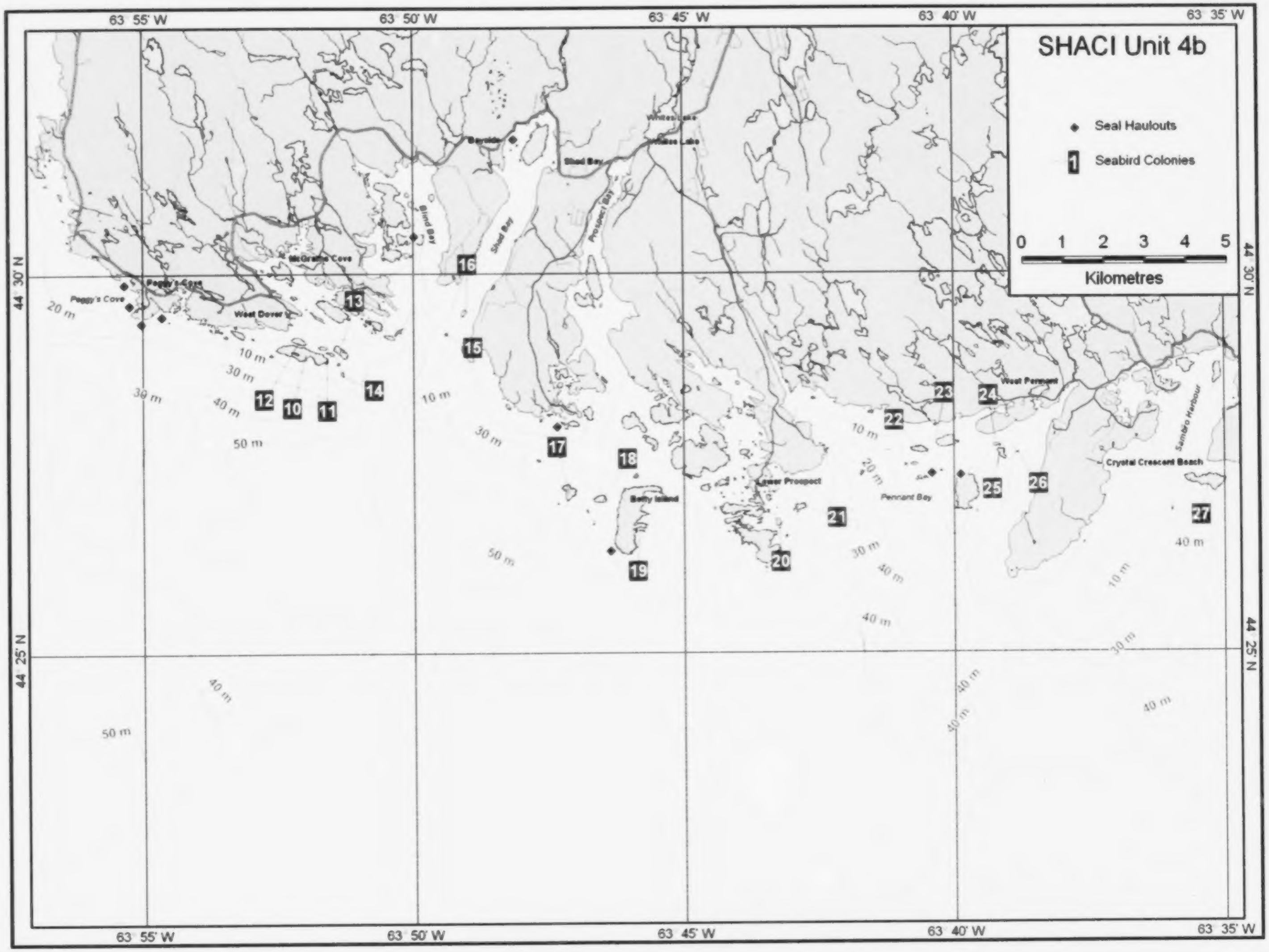

Figure 12-1b: Locations of seabird colonies and seal haulouts in SHACI Unit 4b (based on data from HRMWRCRMP 1996 and Environment Canada Seabird Colonies database 2002). Basemap layers (NRCan).

Table 12-2c: SHACI Unit 5a seabird colony

Map order ID	Colony name	English name summary
27	Sambro Island, Inner	Great Black-backed Gull, Herring Gull, Common/Arctic Tern
28	Sambro Island, unidentified W of	Great Black-backed Gull
29	Sambro Island	Great Black-backed Gull, Herring Gull, Roseate Tern, Common/Arctic Tern
30	McNabs Island	Great Blue Heron, Common/Arctic Tern
31	Devils Island	Great Black-backed Gull, Herring Gull
32	Shut-in Island	Cormorant spp., Great Black-backed Gull, Herring Gull
33	Rat Rock	Great Black-backed Gull, Herring Gull

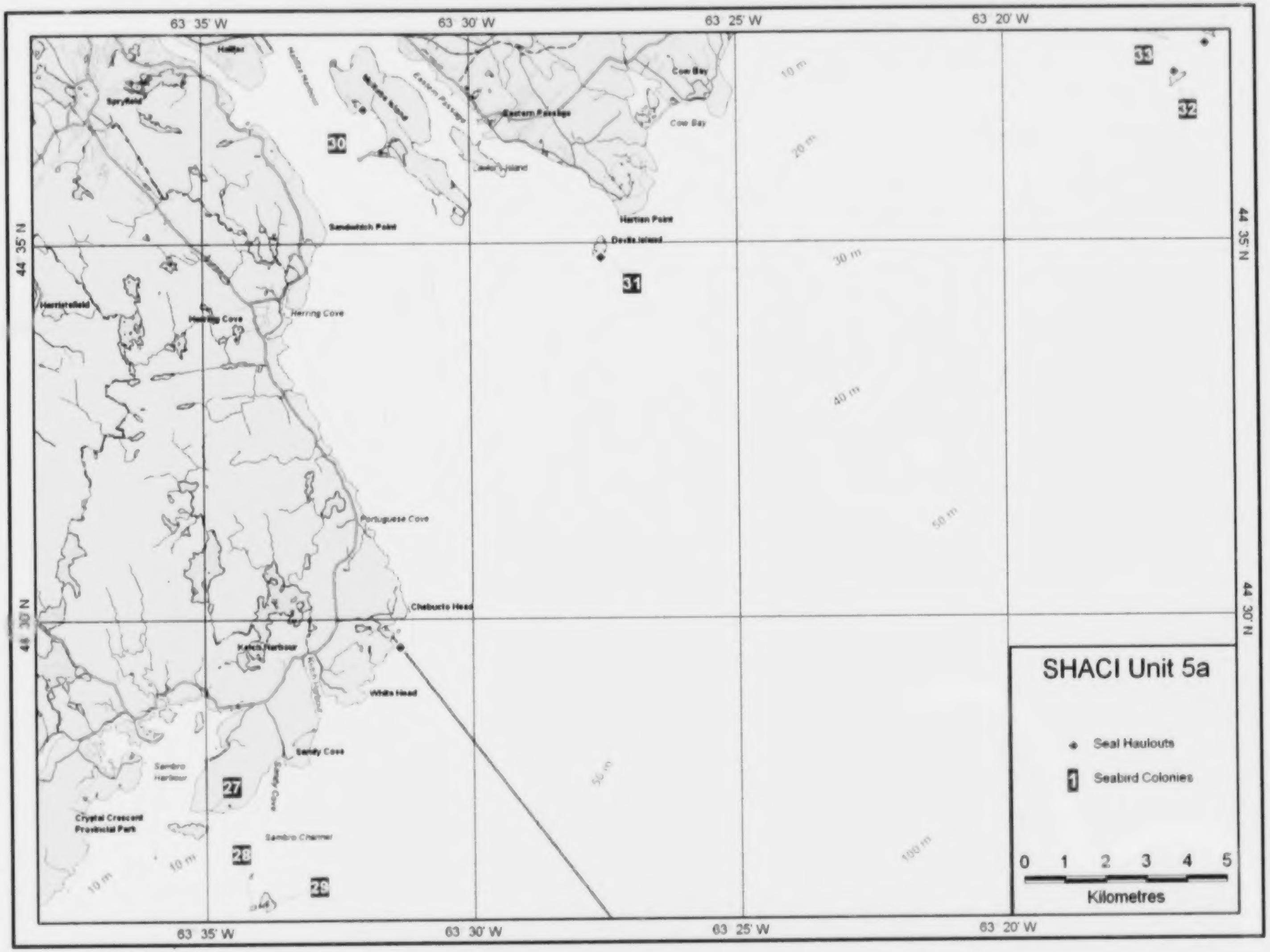

Figure 12-1c: Locations of seabird colonies and seal haulouts in SHACI Unit 5a (based on data from HCESCRMP 1996, HRMWRCRMP 1996 and Environment Canada Seabird Colonies database 2002). Basemap layers (NRCan).

Table 12-2d: SHACI Unit 5b seabird colony

Map order ID	Colony name	English name summary
31	Devils Island	Great Black-backed Gull, Herring Gull
32	Shut-in Island	Cormorant spp., Great Black-backed Gull, Herring Gull
33	Rat Rock	Great Black-backed Gull, Herring Gull
34	Wedge Island, Three Fathom	Great Black-backed Gull, Herring Gull
35	Bisset Lake	Herring Gull
36	Rainbow Haven, West of Skeet Club	Common/Arctic Tern
37	Cole Harbour, unidentified in	Common/Arctic Tern
38	Fisherman's Beach	Roseate Tern
39	Shagrock Point	Common/Arctic Tern

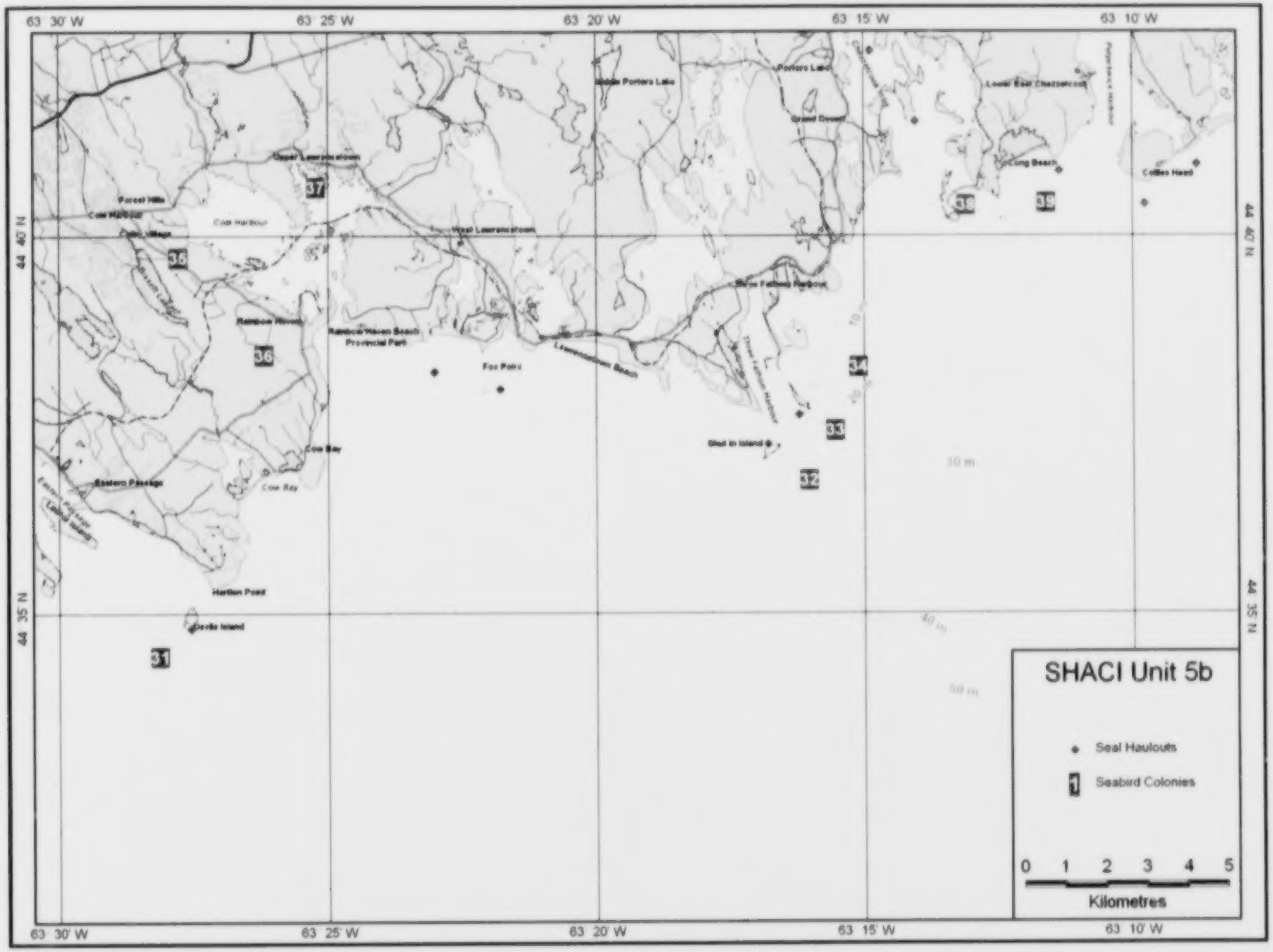

Figure 12-1d: Locations of seabird colonies and seal haulouts in SHACI Unit 5b (based on data from HCESCRMP 1996 and Environment Canada Seabird Colonies database 2002). Basemap layers (NRCan).

Table 12-2e: SHACI Unit 5c seabird colony

Map order ID	Colony name	English name summary
40	Jeddore Rock	Great Black-backed Gull
41	Gull Rock, Clam Bay	Cormorant spp., Great Black-backed Gull, Herring Gull
42	Barren Island (CB)	Double-crested Cormorant, Great Black-backed Gull, Herring Gull
43	Roger Islet	Double-crested Cormorant, Great Black-backed Gull
44	Duck Island (CB)	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Herring Gull
45	Sugarloaf	Great Black-backed Gull, Herring Gull
46	Goose Island (CB)	Great Black-backed Gull
47	Long Island (CB)	Common Eider, Great Black-backed Gull, Herring Gull
48	Egg Island, Clam Bay	Great Black-backed Gull, Herring Gull, Common/Arctic Tern
49	Porter & Laybold Island	Common Eider
50	Laybold Island	Herring Gull
51	Bald Island (CB)	Double-crested Cormorant, Great Black-backed Gull
52	Cutfinger Island	Double-crested Cormorant

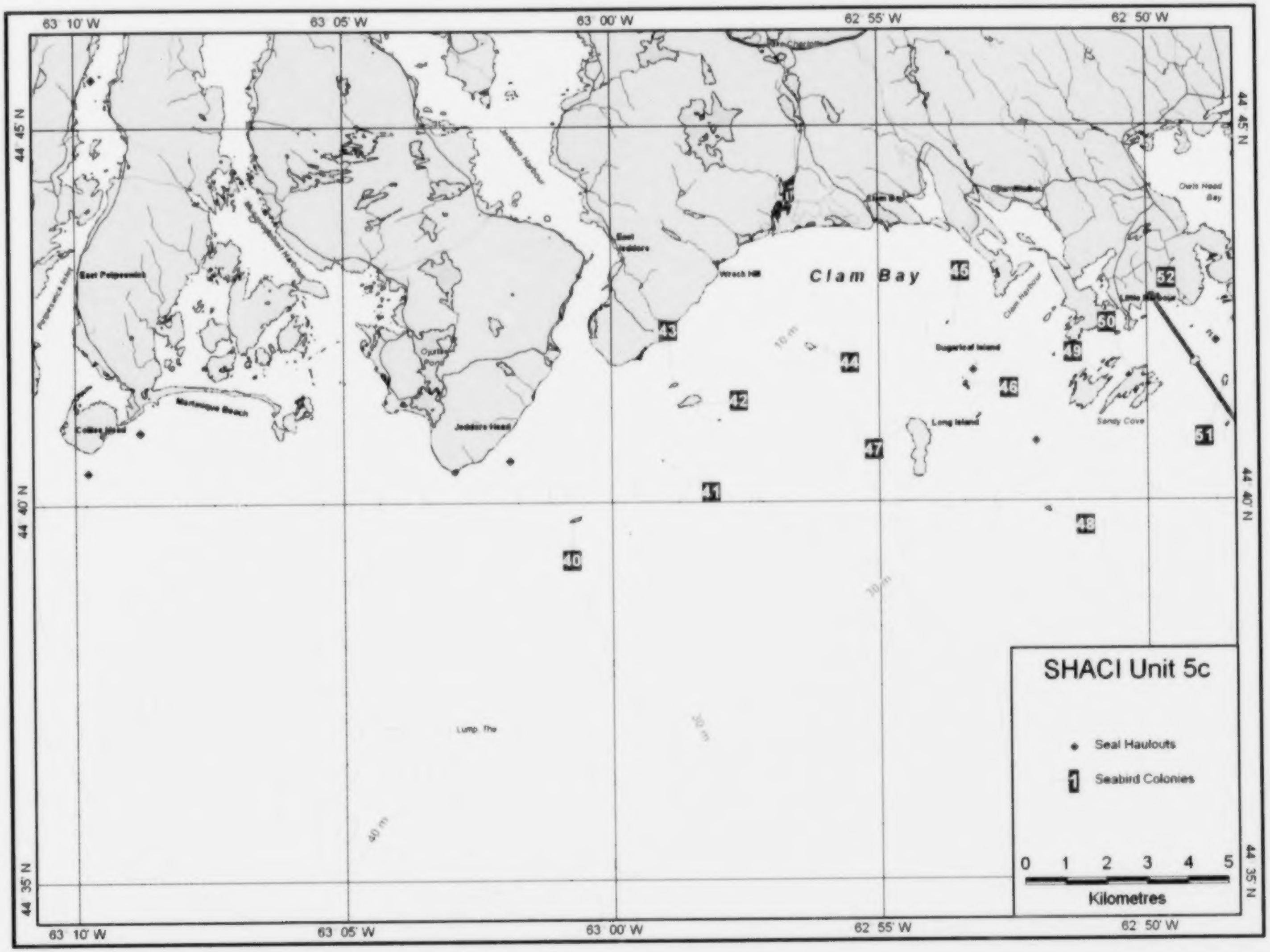

Figure 12-1e: Locations of seabird colonies and seal haulouts in SHACI Unit 5c (based on data from HCESCRMP 1996 and Environment Canada Seabird Colonies database 2002). Basemap layers (NRCan).

Table 12-2f: SHACI Unit 6a seabird colony

Map order ID	Colony name	English name summary
49	Porter & Laybold Island	Common Eider
50	Laybold Island	Herring Gull
51	Bald Island (CB)	Double-crested Cormorant, Great Black-backed Gull
52	Cutfinger Island	Double-crested Cormorant
53	Western Island (NS)	Great Black-backed Gull, Roseate Tern
54	Outer Islands (SH)	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron
55	Stony Island	Great Black-backed Gull, Great Blue Heron, Common/Arctic Tern
56	Gerard Island, unidentified east of	Common Tern
57	Rocks in Taylor Bay	Arctic Tern, Common Tern, Common/Arctic Tern
58	Leslie Island	Cormorant spp., Great Black-backed Gull
59	Hen Island	Arctic Tern, Common Tern
60	Little Guilford Island, North	Great Black-backed Gull
61	Little Guilford Island, Middle	Cormorant spp.
62	Guilford Island	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull
63	Sheet Rock	Great Black-backed Gull
64	Monahan Island	Great Black-backed Gull, Herring Gull
65	Horse Island [W]	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull
66	Sober Island and Sheet Harbour, in between	Arctic Tern, Common Tern

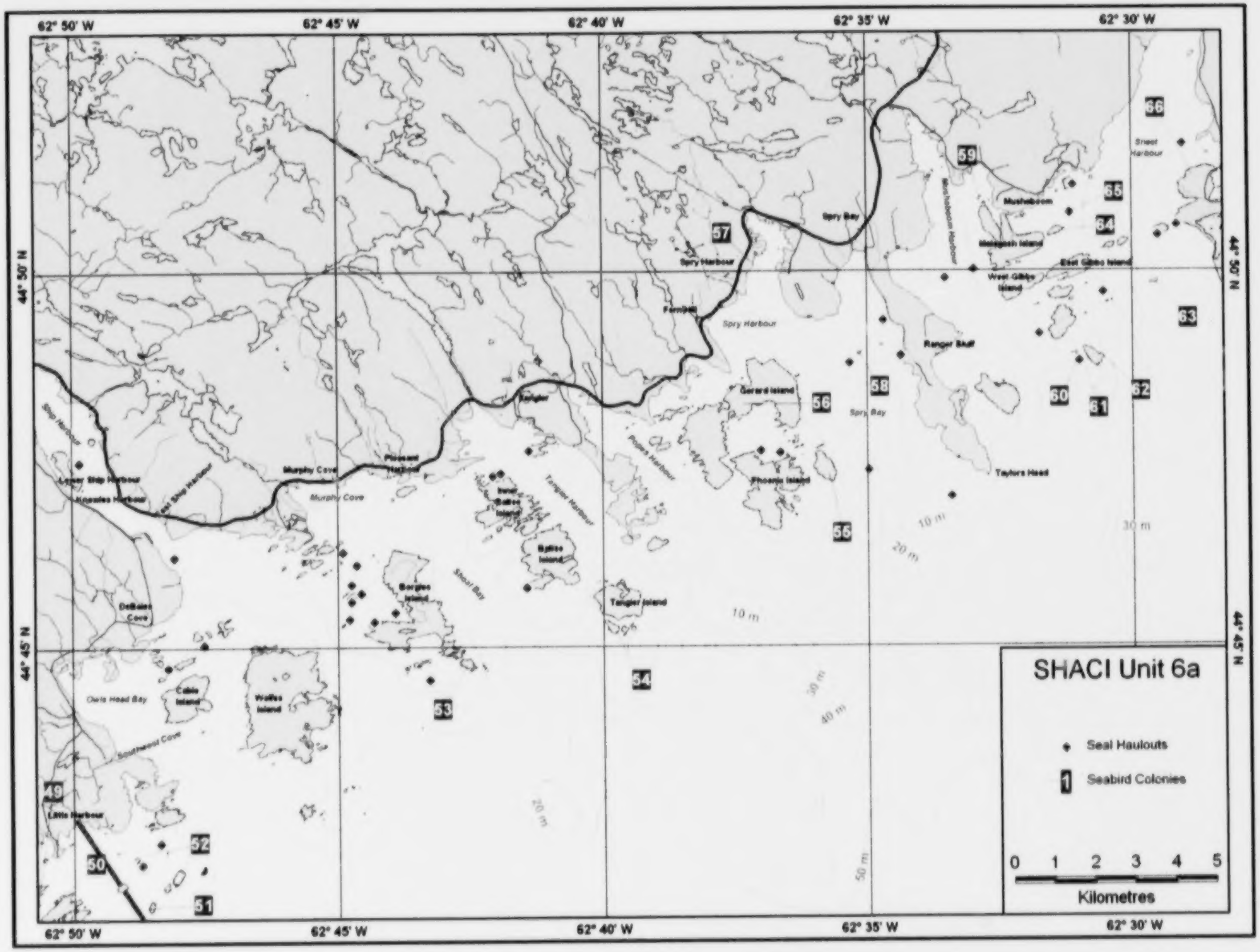

Figure 12-1f: Locations of seabird colonies and seal haulouts in SHACI Unit 6a (based on data from HCESCRMP 1996 and Environment Canada Seabird Colonies database 2002). Basemap layers (NRCan).

Table 12-2g: SHACI Unit 6b seabird colony

Map order ID	Colony name	English name summary
60	Little Guilford Island, North	Great Black-backed Gull
61	Little Guilford Island, Middle	Cormorant spp.
62	Guilford Island	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull
63	Sheet Rock	Great Black-backed Gull
64	Monahan Island	Great Black-backed Gull, Herring Gull
65	Horse Island [W]	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull
66	Sober Island and Sheet Harbour, unidentified between	Arctic Tern, Common Tern
67	Mink Island, unidentified S of	Common Eider, Herring Gull
68	Hardwood Island, Sheet Hbr.	Great Black-backed Gull
69	Mink Island	Common Tern
70	Pumpkin Island (SH)	Black Guillemot, Common Eider, Double-crested Cormorant, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
71	Brother Islands West	Common Eider, Cormorant spp., Great Black-backed Gull, Great Cormorant, Herring Gull, Leach's Storm-Petrel
72	Brother Islands East	Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
73	Brother Islands	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Cormorant,
74	Beaver Island	Great Black-backed Gull, Herring Gull, Common/Arctic Tern
75	Horse Island, SE of	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
76	Horse Island	Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron
79	Speck Island	Common Eider, Cormorant spp., Double-crested Cormorant, Great Black-backed Gull, Great Cormorant, Herring Gull
80	Sutherland Islet	Common Tern
81	Sutherland Island & Islet	Common Eider, Double-crested Cormorant, Great Black-backed Gull
82	Sutherland Island	Common Eider, Common/Arctic Tern
83	The Pancake	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull
84	Sandy Island (BH)	Common Eider, Great Black-backed Gull, Herring Gull, Common/Arctic Tern
85	Little Island	Arctic Tern, Common Tern
86	Bald Harbour Islands	Common Eider, Great Black-backed Gull, Leach's Storm-Petrel
87	Bold Harbour	Common Eider, Great Black-backed Gull, Leach's Storm-Petrel
88	Big Harbour Island	Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
89	Little Harbour Island	Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel

Map order ID	Colony name	English name summary
90	Outside Eastern Harbour Island	Common Eider, Herring Gull
91	Inside Eastern Harbour Island	Common Eider, Great Black-backed Gull, Great Blue Heron, Herring Gull, Leach's Storm-Petrel
92	Bird Islands, inner west	Arctic Tern, Common Eider, Common Tern, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel, Razorbill, Roseate Tern, Common/Arctic Tern
93	Bird Islands	Common Eider, Common Tern, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
94	Bird Islands, outer west	Common Eider, Great Black-backed Gull, Leach's Storm-Petrel, Common/Arctic Tern
95	Bird Islands, outer east	Common Eider, Great Black-backed Gull, Leach's Storm-Petrel, Common/Arctic Tern
96	Bird Islands, inner east	Common Eider, Common Tern, Great Black-backed Gull, Leach's Storm-Petrel
97	Goose Island (BH)	Common Eider, Great Black-backed Gull, Herring Gull
98	Long Island (BH)	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull, Leach's Storm-Petrel, Common/Arctic Tern
99	Quoddy, unidentified off	Roseate Tern, Common/Arctic Tern
100	Bay of Islands	Common/Arctic Tern
101	Brokenback Island	Common Eider, Great Black-backed Gull, Great Blue Heron, Herring Gull, Leach's Storm-Petrel
102	Gold Island	Common Eider, Great Black-backed Gull
103	Torpey Passage, unidentified in	Common/Arctic Tern
104	Halibut Island, Big	Common Eider, Great Black-backed Gull, Great Blue Heron, Leach's Storm-Petrel
105	Halibut Island, Outer	Great Black-backed Gull
106	Middle Halibut Island	Common Eider, cormorant spp., Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull, Leach's Storm-Petrel
107	Little Halibut Island	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Leach's Storm-Petrel
108	Halibut Island, Inner	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
109	Necum Teuch, gravelbar off	Common Eider, Common Tern, Roseate Tern
110	Calf Island and Low Island, unidentified between	Arctic Tern, Common Tern, Roseate Tern
111	Long & Gulch Island, unidentified between	Roseate Tern
112	Hardwood Island (NTB)	Roseate Tern
113	Tern Island	Arctic Tern, Common Tern
114	Orkney, unidentified SE of	Great Black-backed Gull, Herring Gull
115	Ram Island, near Orkney	Common Eider, Great Black-backed Gull, gull spp., Herring Gull, Common/Arctic Tern
116	Little Goose Island	Common Eider, Great Black-backed Gull
117	Tuffin Island	Common Eider
118	Bowen Ledge	Great Cormorant
119	Camp Island	Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
120	White Island, Big peninsula	Common Eider, Great Black-backed Gull, Leach's Storm-Petrel

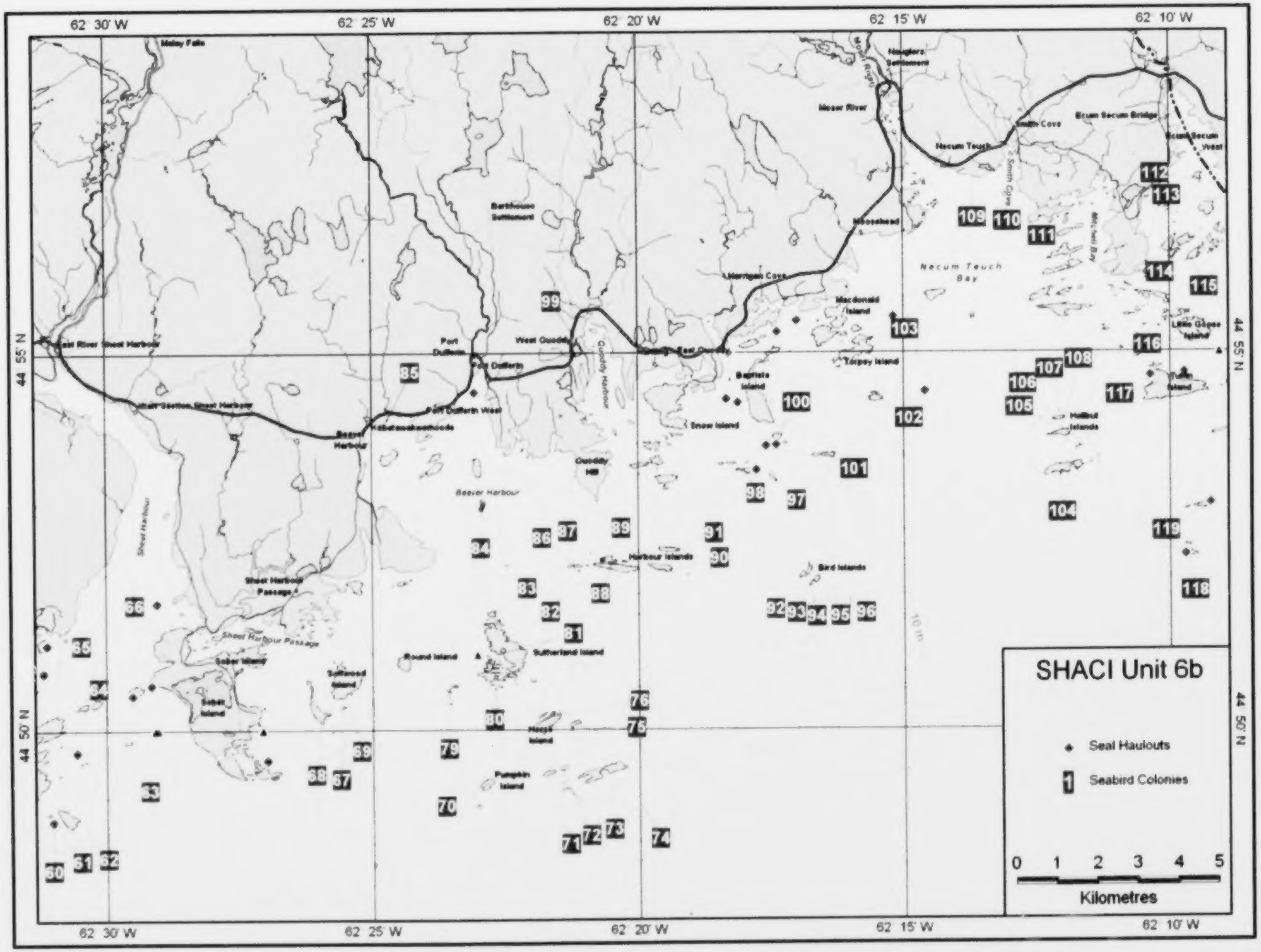

Figure 12-1g: Locations of seabird colonies and seal haulouts in SHACI Unit 6b (based on data from HCESCRMP 1996 and Environment Canada Seabird Colonies database 2002). Basemap layers (NRCan).

Table 12-2h: SHACI Unit 6c seabird colony

Map Order ID	Colony name	English name summary
104	Halibut Island, Big	Common Eider, Great Black-backed Gull, Great Blue Heron, Leach's Storm-Petrel
105	Halibut Island, Outer	Great Black-backed Gull
106	Middle Halibut Island	Common Eider, Cormorant spp., Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull, Leach's Storm-Petrel
107	Little Halibut Island	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Leach's Storm-Petrel
108	Halibut Island, Inner	Common Eider, Double-crested Cormorant, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
109	Necum Teuch, gravelbar off	Common Eider, Common Tern, Roseate Tern
110	Calf Island and Low Island, unidentified between	Arctic Tern, Common Tern, Roseate Tern
111	Long & Gulch Island, unidentified between	Roseate Tern
112	Hardwood Island (NTB)	Roseate Tern
113	Tern Island	Arctic Tern, Common Tern
114	Orkney, unidentified southeast of	Great Black-backed Gull, Herring Gull
115	Ram Island, near Orkney	Common Eider, Great Black-backed Gull, gull spp., Herring Gull, Common/Arctic Tern
116	Little Goose Island	Common Eider, Great Black-backed Gull
117	Tuffin Island	Common Eider
118	Bowen Ledge	Great Cormorant
119	Camp Island	Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
120	White Island, Big, peninsula	Common Eider, Great Black-backed Gull, Leach's Storm-Petrel
121	Camp Island, unidentified east of	Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
122	Round Island	Common Eider, Great Black-backed Gull, Leach's Storm-Petrel
123	White Islands	Great Black-backed Gull, Great Blue Heron
124	White Island, Big, main section	Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel
125	Little White Island	Common Eider, Cormorant spp., Double-crested Cormorant, Great Black-backed Gull, Great Cormorant, Herring Gull, Leach's Storm-Petrel
126	Nags Head and Hapes Point, unidentified between	Arctic Tern
127	Gull Ledge	Cormorant spp., Great Black-backed Gull, Leach's Storm-Petrel, Common/Arctic Tern
128	Barren Island (NTB)	Common Eider, Great Black-backed Gull, Great Blue Heron, Herring Gull
129	Thrum Cap Islet	Roseate Tern
130	Thrumcap Island (NTB)	Arctic Tern, Common Eider, Common Tern, Great Black-backed Gull
131	Fancy's Point	Common Tern, Common/Arctic Tern
132	Spanish Ship Bay, unidentified in	Common Tern
133	Liscomb Harbour, unidentified in	Common Tern
134	Tobacco Island	Common Eider, Cormorant spp., Great Black-backed Gull, Great Blue Heron
135	Wedge Island, Liscomb Hbr	Great Black-backed Gull, Herring Gull

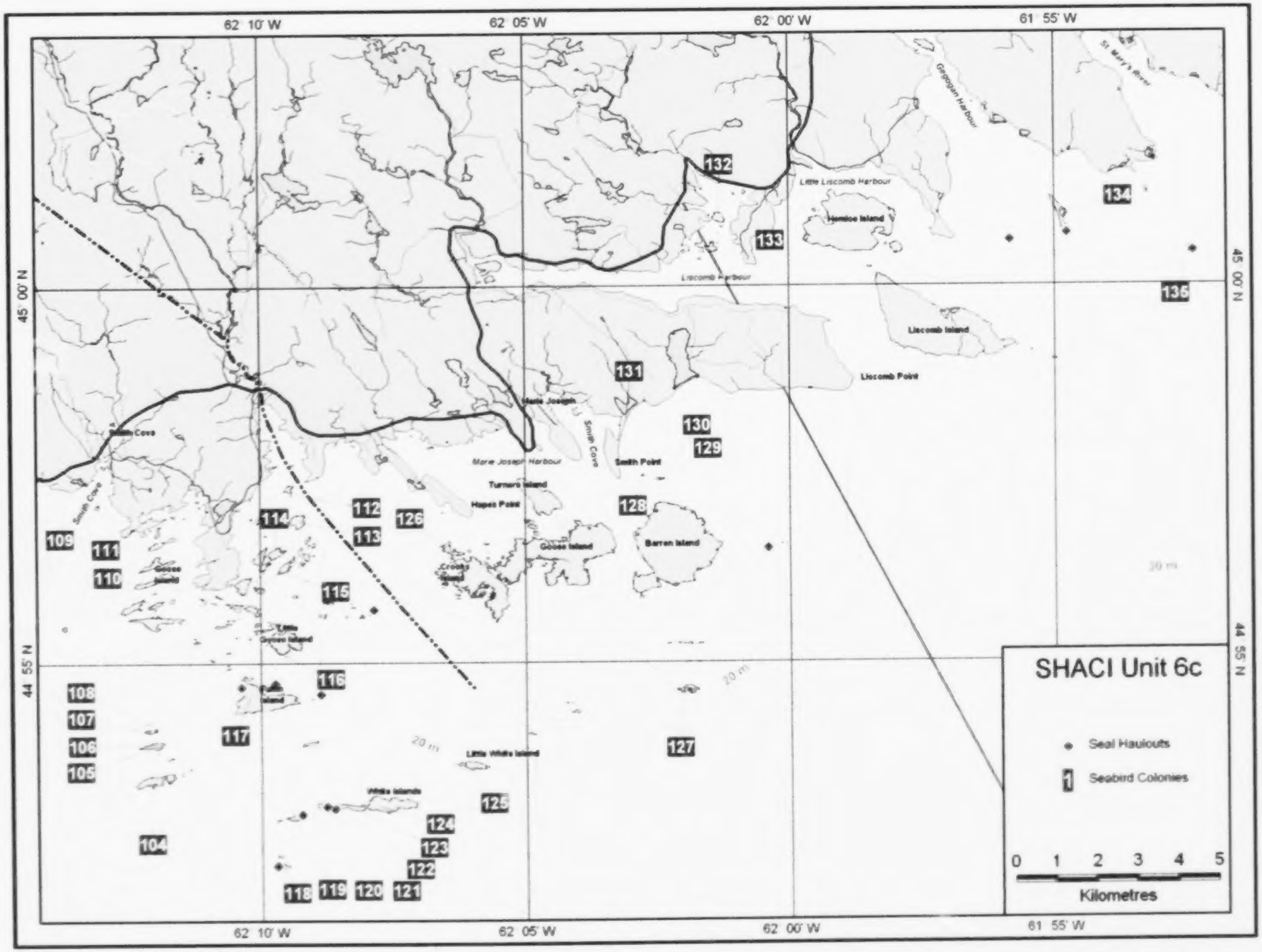

Figure 12-1h: Locations of seabird colonies and seal haulouts in SHACI Unit 6c (based on data from GCCRMP 1994, HCESCRMP 1996 and Environment Canada Seabird Colonies database 2002). Basemap layers (NRCan).

At least 16 non-breeding species occur along the HRM coast rarely to commonly during some part of the year. These include both pelagic and neritic visitors during the summer and fall, migrants during spring and fall, and species overwintering along the Atlantic coast (Table 12-3) (Paquet and Chardine 2001). Important overwintering sites for seabirds in this coastal area have not been identified.

Table 12-3: Non-breeding pelagic seabirds known to occur in SHACI Units 4-6 (compiled from Tufts 1986 and Fenton 1993)

Species	Visitation period
Non-breeding visitor, summertime	
Common black-headed Gull *Larus ridibundus*	Occasionally over-winters
Laughing Gull *Larus atricilla*	
Migrating along coast	
Pomarine Jaeger *Stercorarius pomarinus*	Fall and Spring
Parasitic Jaeger *Stercorarius parasiticus*	Fall and Spring
Long-tailed Jaeger *Stercorarius longicaudus*	Fall and Spring
Ring-billed Gull *Larus delawarensis*	Fall and Spring; few spend summer
Bonaparte's Gull *Larus philadelphia*	Fall and Spring
Overwintering populations	
Iceland Gull *Larus glaucoides*	October to April
Glaucous Gull *Larus hyperboreus*	October to May
Ivory Gull *Pagophila eburnean* (rare)	Fall to Spring
Great Skua *Catharacta skua*	Found year-round, no breeding information known
Ring-billed Gull *Larus delawarensis*	
Occasional visitors/transients/vagrants	
Mew Gull *Larus canus*	Late winter
Magnificent Frigatebird *Fregata magnificens*	Late fall
Northern Gannet *Sula bassanus*	Late Winter to Early Fall
Gull-billed Tern *Sterna nilotica*	Summer to Early Fall
Least tern *Sterna antillarum*	Summer

Shorebirds and marsh birds of coastal wetlands

Migration

Shorebirds and marsh birds use Nova Scotia's coastal habitats as refuelling stops during their transcontinental migrations, and some also breed in the area. Shorebirds and marsh birds are primarily distinguished by their habitat preference; shorebirds usually prefer coastal shores and marsh birds prefer either freshwater or saltwater marshes. Nova Scotia marsh birds include herons, rails, bitterns, snipe, and less commonly, egrets. Shorebirds include plovers, sandpipers, godwits, yellowlegs, ruff, dunlin and willets, among others.

During the fall migration through Atlantic Canada, over 500 000 shorebirds feed on a variety of small invertebrates in the Bay of Fundy's tidal mudflats. Smaller numbers, but a wider diversity of shorebird species are found along the Atlantic coast (Table 12-4). The increase in species diversity along the Atlantic coast is due to the greater variety in available habitats for foraging and resting (P. Lane and Associates 1992). As examples, willets commonly nest in tidal marshes, Greater and Lesser Yellowlegs forage there, and Spotted Sandpipers are widespread along the coast (Davis and Browne 1996). Chezzetcook and Lawrencetown are important salt marshes in SHACI Unit 5 (Stewart and White 2001). Marsh birds are far less common in Nova Scotia than shorebirds. Only the Great Blue Heron is found commonly in summer and the Sora uncommonly. All other rails, bitterns and egrets are found only rarely throughout the summer and almost never in winter (Tufts 1986). The population abundance of rails, bitterns and snipe may, however, be underestimated; these species are inconspicuous, considered difficult to detect, and inhabit areas not often readily accessible to surveyors (USFWS and USGS 1999).

Several informal shorebird surveys are conducted through the Maritimes Shorebird Survey (CWS 2002a), Maritimes Breeding Bird Survey (CWS 2003), Audubon Christmas Bird Count (Audubon 2003) and others at several locations within SHACI Units 4-6, including Peggy's Cove, Sheet Harbour, Cooks Beach, Conrod's Beach, Conrod's Island, West Chezzetcook and Lawrencetown River (Maybank 1995, CWS 2002a). Conrod's Beach, where 12 shorebird species were recorded in 2001 (CWS 2002a), is arguably the most significant shorebird area in SHACI Units 4-6, although the surrounding Cole Harbour area hosts three of these survey areas (Cooks Beach, Conrod's Beach and Conrod's Island) and has a larger number of observed species overall. The number of shorebird species recorded in SHACI Units 4-6 is likely underestimated compared to other locations within Nova Scotia because fewer surveys, usually one per site, were conducted here than elsewhere, where upwards of five surveys per site are common (CWS 2002a). Several uncommon species sighted at Cole Harbour include Dunlin, Common Snipe and Pectoral Sandpipers (CWS 2002a).

Table 12-4: Shorebird and marsh bird species and locations recorded in SHACI Units 4, 5 and 6

	Abundance status in Canada*	Overall population trend in Canada**	Cooks Beach	Conrod's Beach	Conrod's Island	Lawrencetown River	Martinique Beach	Cole Harbour	Chebucto Head	Three Fathom Harbour	Petpeswick Inlet	West Chezzetcook	Hartlen Point	Chezzetcook Inlet	Sambro Light	Russel Lake	Halifax	Prospect	Musquodoboit	Clam Harbour Beach	Unspecified location in Halifax County
den Plover *s dominica*	C	▼▼						X													
ellied Plover *s squatarola*	C	▼▼	X	X	X	X		X			X										
rling *Calidris alba*	C	▼▼						X													
d Plover *radrius semipalmatus*	C	▼▼	X	X		X		X				X					X				
radrius melodus	E			X			X	X												X	
haradrius vociferus	C	▼▼	X										X								
orus semipalmatus	C	◀▶	X	X	X	X		X				X								X	
rel *Numenius phaeopus*	C	◀▶	X			X	X						X								
r Yellow Legs *a melanoleuca*	C	◀▶	X	X	X	X	X	X		X		X		X							
r Yellow Legs *inga flavipes*	C	▼▼	X	X	X	X	X			X		X									
curvirostra americana	R	(-)						X		X											
dy Turnstone *ria interpres*	C	▼▼	X					X													
Calidris canutus	C	▼▼	X					X													
sonian Godwit *osa haemastica*	R	▼				X															
ed Godwit *Limosa fedoa*	R	▼						X							X						

	Abundance status in Canada*	Overall population trend in Canada**	Cooks Beach	Conrod's Beach	Conrod's Island	Lawrencetown River	Martinique Beach	Cole Harbour	Chebucto Head	Three Fathom Harbour	Petpeswick Inlet	West Chezzetcook	Hartlen Point	Chezzetcook Inlet	Sambro Light	Russel Lake	Halifax	Prospect	Musquodoboit	Clam Harbour Beach	Unspecified location in Halifax County
st Sandpiper *inutilla*	C	▼▼	X	X			X	X				X									X
dpiper *elanotos*	C	◀▶	X					X													
piper *titis macularia*	C	▼▼						X													
ris maritima	C	▼▼						X													
n *Calidris alpina*	C	▼▼		X			X	X													
sted Sandpiper *s subruficollis*	R	▼		X									X								
ped Sandpiper *ris fuscicollis*	C	◀▶		X				X													
Philomachus pugnax								X													
ed Dowitcher *nodromus griseus*	C	▼▼	X	X		X		X				X									
on Snipe *go gallinago*	C	▼▼	X	X				X													
s lentiginosus								X									X				
t Bittern																		X	X		
Rallus limicola								X								X					
Porzana carolina								X													
Heron *erodias*																					X
ron *erulea*								X													

	Abundance status in Canada*	Overall population trend in Canada**	Cooks Beach	Conrod's Beach	Conrod's Island	Lawrencetown River	Martinique Beach	Cole Harbour	Chebucto Head	Three Fathom Harbour	Petpeswick Inlet	West Chezzetcook	Hartlen Point	Chezzetcook Inlet	Sambro Light	Russel Lake	Halifax	Prospect	Musquodoboit	Clam Harbour Beach	Unspecified location in Halifax County
ron								X													
ret *smerodius albus*																	X				
Egretta thula								X													X

*A = abundant, C = common, R = regular, U = uncommon, Sc = scarce, Sp = special concern, T = threatened, E = endangered (Donaldson et al. 2000)

** ▼▼ Indicates predominantly negative trends or changes across analyses with at least one significantly negative trend or change. ▼ Indicates that analyses include predominantly negative trends or changes or only estimate available is negative.

◄► Indicates that analyses include both positive and negative trends. (-) Indicates a negative change (Donaldson et al. 2000)

Compiled from BSC (2002), Davis and Browne 1996, Tufts 1986, Fenton 1993, Maybank 1995, CWS 2002a, Environment Canada 2002b & c

Breeding

The Piping Plover is one of Canada's most endangered shorebirds, and the eastern (*melodus*) race is listed as endangered at both national and provincial levels (COSEWIC 2002, NSDNR 2002). Nova Scotia's Atlantic coast is home to many of the white sand and pebble beaches where Piping Plovers prefer to nest (NSDNR 2002). In 2001, forty five breeding pairs were counted in a census in Nova Scotia (Ferland and Haig 2002). In SHACI Units 4-6, Lock et al. (1994) identified known nesting sites at Clam Harbour Beach, Martinique Beach, Conrod's Beach, and Cole Harbour. The HCESCRMP (1996) also identified Piping Plover nests in these locations, among others at Conrod's Beach west of Fox Point, Long Beach at Meisener's Lake, and the southwest shore of Jeddore Head. However, a Piping Plover breeding census in 2001 indicated that in SHACI Units 4-6, Piping Plovers were found only on Martinique Beach (one breeding pair, three adults) (Ferland and Haig 2002).

Willets are large, conspicuous, and territorial shorebirds dependent on salt marsh habitats, where they feed in the shallow waters. Fewer than 750 pairs are known to inhabit the Maritimes provinces as a whole and several are found along the shores between Hartlen Point and Clam Bay, in SHACI Unit 5.

Waterfowl

Coastal marshes, wetlands and offshore islands of the HRM are used by migrating and resident waterfowl for breeding and overwintering (Table 12-5). While waterfowl, including ducks, geese, mergansers and loons, are distributed along the coast fairly evenly during winter, survey coverage through the remaining seasons is variable with particularly little summer data over much of the coast (Lock et al. 1994). The lack of summer survey data means that we do not know very much about the numbers, locations and success of breeding colonies along Nova Scotia's coast.

Some waterfowl are resident year-round, while others visit seasonally to breed during summer or spend the winter months (overwinter). Many birds move through the area during fall en route to southern destinations. The general breeding pattern in HRM waters is the same as elsewhere for both resident and non-resident waterfowl. Migrants typically arrive between March and June and depart by the end of October. Breeding and egg laying commence as early as March, with most chicks hatched by June or early July. Mothers and young usually leave the breeding area last in late July and August (Tufts 1986).

Although summer survey coverage is poor, Lock et al. (1994) state that Common Eiders (*Somateria mollissima*) are the only ducks abundant in Nova Scotia's coastal zone at that time. They are most commonly found on islands within the ESIWMA, within 10 km of the shores between Beaver Harbour and Ecum Secum (Figure 12-1g). This area is used by both breeding and non-breeding individuals, and supports over 4000 breeding eiders, the densest concentration on the Atlantic coast of Nova Scotia. They represent one-quarter of the total breeding population in this province and over 2.5% of the total North American Common Eider population (BSC 2002, NSDNR 1977). P. Lane and Associates (1992) identified the Eastern Shore as an area of prime significance for the number of Common Eider nesting sites and the general abundance of colonial waterbirds overall.

Table 12-5: Breeding and overwintering waterfowl species occurring in SHACI Units 4, 5 and 6

Species*	Breeding	Over-wintering	Spring & fall transient	Population trend in Eastern Canada[A,B]
American Black Duck *Anas rubripes*	✓	✓		Increasing
Harlequin Duck *Histrionicus histrionicus*		✓		Increasing
American Wigeon *Anas americana*	✓			Increasing
Ring-necked Duck *Aythya collaris*		✓		Increasing
Green Winged Teal (*Eurasian Anas crecca crecca* and North American subspecies & *Anas crecca carolinensis*		✓		Increasing
Blue-winged Teal *Anas discors*	✓			Decreasing
Barrow's Goldeneye *Bucephala islandica*		✓		Decreasing**
Common Goldeneye *Bucephala clangula*		✓		Increasing
Common Eider *Somateria mollissima*	✓	✓		Decreasing
White-winged Scoter *Melanitta fusca*		✓		No clear trend
Surf Scoter *Melanitta perspicillata*			✓	Stable
Black Scoter *Melanitta nigra*			✓	Stable
Common Merganser *Mergus merganser*	✓	✓		Increasing
Red Breasted Merganser *Mergus merganser*	✓	✓		Decreasing
Hooded Merganser *Lophodytes cucullatus*		✓		Increasing
Northern Pintail *Anas acuta*	✓	✓		No clear trend
Mallard *Anas platyrhynchos*		✓		Increasing
Northern Shoveler *Anas clypeata*	✓			Increasing
Common Loon *Gavia immer*	✓	✓		Increasing
Canada Goose *Branta canadensis canadensis*	✓	✓		No clear trend
Brant Goose *Branta bernicla*		✓		Increasing
Lesser Snow Goose *Chen caerulescens caerulescens*			✓	Vastly increasing

* Species list compiled from Fenton (1993), Tufts (1986), and Audubon (2003).

[A] CWS Wildlife Committee (2002), [B] Bordage and Lepage (2002). Trend reported from [A] unless unavailable for Atlantic region, then reported from [B].

** Suspected trend

Harlequin Ducks (*Histrionicus histrionicus*) are small marine ducks whose eastern Canada population is one of four in the world, listed nationally as a species of Special Concern (CWS 2002b) and provincially as Endangered (NSDNR 2002). Like the Common Eider, they occupy the ESIWMA, although only during winter months. Lock et al. (1994) estimated that up to 150 Harlequin Ducks were found on Nova Scotia's Atlantic coast, with about 30 birds regularly seen off Halifax. Although few trend data are available for this species in the Maritimes, available information suggests an increase in the last five years. It is estimated that almost 600 Harlequin Ducks winter off the coast of Nova Scotia, although because of the extent of coast and occasional sightings of Harlequin Ducks from previously unknown locations, it is likely that these are minimum estimates (Boyne pers. comm. 2005). In SHACI Units 4-6, Prospect and the ESIWMA are known wintering sites for the Harlequin Duck. Surveys counts in 2002 indicate that there were 57 Harlequin Ducks at Prospect and 355 in the ESIWMA (Boyne pers. comm. 2005). The tendency of Harlequin Ducks to concentrate in traditional wintering areas (NSDNR 1996) makes them susceptible to local disturbance and likely responsive to appropriate habitat protection measures.

Canada Geese (*Branta canadensis canadensis*) in Nova Scotia are part of the Atlantic population, nesting in northern Quebec, on the eastern shore of Hudson Bay and on the Ungava peninsula (CWS 2002a). In contrast to small, dispersed populations exhibited by other coastal waterfowl, the Canada Goose is found in local dense concentrations. Its preferred locations along Nova Scotia's coast are Yarmouth, the Port Joli sanctuary complex and the Musquodoboit area (including Cole Harbour, Petpeswick and Chezzetcook) (Lock et al. 1994, MacKinnon et al. 1994). The total population between these three sites is estimated at 10 000 birds, accommodating most of the Atlantic region's overwintering geese. Nearly 6500 are in the Musquodoboit area, taking advantage of the often ice-free intertidal flats.

Raptors

Two birds of prey in this region are largely associated with tidal estuaries and shallow coastal habitats. Both the Osprey (*Pandion haliaetus)* and Bald Eagle (*Haliaeetus leucocephalus)* nest and forage along Nova Scotia's coast, including SHACI Units 4-6.

Ospreys are Nova Scotia's provincial bird and summer migrants to the province. Non-breeding sub-adults remain on southern wintering grounds, thus all visiting adults are breeders. There are approximately 400 breeding pairs province-wide. Usually arriving in April, ospreys mostly live in coastal areas with shallow bays or estuaries, with generally isolated nesting sites (Tufts 1986, Towers 1995). Systemic surveys of osprey distribution are unknown but several nest locations were documented in the Halifax and Guysborough County Coastal Resource Mapping Projects (GCCRMP 1994, HCESCRMP 1996, HRMWRCRMP 1996). Maps resulting from these projects show nearly 40 osprey nesting sites between Hubbards and Liscomb Harbour (Table 12-6). Osprey chicks fledge in August, and the birds fly south by mid-October (Tufts 1986).

Bald Eagles are resident species with over 200 breeding pairs counted in province. The largest concentration of nests are found around Bras d'Or Lake in Cape Breton, where many birds will stay throughout fall and winter providing they find enough to eat. They disperse more widely along coastal areas during fall. Eagle nesting sites in SHACI Units 4-6 are identified in the Coastal Resource Mapping series.

Table 12-6: Osprey and Bald Eagle nest sites in SHACI Units 4-6 (compiled from GCCRMP 1994, HCESCRMP 1996, HRMWRCRMP 1996)

Species	Nest Locations		
	Hubbards – Chebucto Head	**Chebucto Head – Clam Bay**	**Clam Bay – Liscomb Harbour**
Bald Eagle *Haliaeetus leucocephalus*	• Fox Point • Kieley Lake • Croucher Island • Troup Island • Upper Tantallon • Black Point • Dover Soi	• Lawlor Island • Goose Lake • Martinique Beach • Upper Petpeswick Inlet • Gunner Island • Petpeswick Lake • Eagle Rocks • Upper Jeddore East Arm	• Abbiecombeck Lake • Second Lake • Layboldts Island • Upper Ship Harbour • Monaghan Island • Outer Island • Newcomb Lake • Phoenix Island • Gerard Island
Osprey *Pandion haliaetus*	• Kieley Lake • Wood Island • Franks George Island • Whynachts Point • Black Point • Prospect Bay • Ferguson's Cove • York Redoubt	• McNab's Island • Lawlor Island • Lawrencetown Lake • Echo Lake • Goose Lake • Upper Petpeswick Inlet • Francis Nose Island • Inner Jeddore Head • Upper Jeddore East Arm	• Barren Island • Long Island • Owls Head Bay • Owls Head Bay mouth, south bar • Upper Ship Harbour • Friar Island • Passage Island area (3) • Charles Island area (4) • Baltee Island • Phoenix Island • Gerard Island • Pyches Island • Salisbury Island • Sheet Harbour • Sheet Harbour Passage

Significant bird areas

Although seabirds, shorebirds, waterfowl and other birds are known to frequent several parts of the coast, certain areas have received official recognition as being more important for bird habitat than others. Several organizations and individuals have identified significant bird habitats in SHACI Units 4-6 (Table 12-7).

Table 12-7: Significant bird areas and their associated species (compiled from Lock et al. 1994 and BSC 2002)

Identified bird area	Designation/recognition	Species	
Musquodoboit	• IBA • Musquodoboit Harbour RAMSAR Site • Martinique Beach Game Sanctuary (provincial) • Martinique Beach Provincial Park (including marine component) • Waterfowl banding station	• American Black Duck • Canada Goose • Piping Plover • Green-winged Teal • Blue-winged Teal • Great Blue Heron • Common Snipe • Short-billed Dowitcher • Least Sandpiper	• Semipalmated Sandpiper • Spotted Sandpiper • Stilt Sandpiper • Purple Sandpiper • Greater Yellowlegs • Lesser Yellowlegs • Black-bellied Plover • Ruddy Turnstone
Eastern Shore Islands	• IBA (includes inshore islands between Clam Harbour and Ecum Secum) • Eastern Shore Wildlife Management Area (Provincial) • Little White, Brokenback, Horse, Pumpkin, and Long Islands recognized by NS Special Places Program (1991) and International Biological Programme (1974)	• Common Eider • Harlequin Duck • White-winged Scoter • Black Scoter • Surf Scoter • Leach's Storm-Petrel • Great Blue Heron • Osprey • Bald Eagle	
Cole Harbour	• Rainbow Haven Beach Provincial Park • Cole Harbour Heritage Park	• Piping Plover • Willet • Great Blue Heron	
Pearl Island	• Provincial Wildlife Management Area	• Atlantic Puffin • Razorbill • Black Guillemot • Leach's Storm-Petrel • Tern breeding habitat	

Threats to marine birds

Coastal areas present several potential threats, of both human and non-human origin, to marine birds.

Fishing

Overfishing
Many marine birds feed on many commercially fished species. If the populations of these fish species become depleted by overfishing, birds will be left with less prey. This can potentially reduce food availability to marine birds which are particularly dependent on local food sources while nesting.

Bycatch
Diving seabirds can become caught in fishing nets or get caught on fishing longlines.

Water and habitat pollution

Water, sediments and biota are all vulnerable to pollution, especially in coastal environments. Potential pollution sources include municipal and industrial effluents, dredging and ocean dumping, wharves, coastal structures and associated activities, aquaculture, persistent marine litter, and toxic phytoplankton. Halifax Harbour sediments are among the most contaminated in the world, and studies of resident mussels, lobsters and flounder show high levels of heavy metals and hydrocarbons demonstrative of the heavily industrialized harbour (Stewart and White 2001). Since birds are often at or near the top of food webs, they may be adversely affected by these contaminants; birds that consume large quantities of contaminants from organisms in lower food web positions may accumulate high concentrations of contaminants.

The overuse and misuse of chemical pesticides on land can lead to contamination in the marine environment. Chemicals sprayed on farm fields, forested areas and municipalities can reach the coast through runoff. Coastal birds can ingest pesticides when feeding in coastal ponds and marshes. These pesticides, although not intended for birds, can have serious effects. For example, pesticides such as DDT (discontinued in Canada in the 1970s) persist for decades and build up in the food chain such that birds can accumulate a lethal dose over time.

Human disturbance to breeding colonies

Marine bird colonies are typically found in isolated locations. Any disturbance to these locations (be it from increased boat traffic, coastal development, increased tourism, etc.) may cause increased stress levels that may negatively affect breeding success and cause birds to abandon breeding altogether (Environment Canada 2001).

A particular case is the endangered shorebird, the Piping Plover, whose nesting and fledgling success is severely impacted by human disturbance to their nesting areas. Piping Plovers nest on open white sand beaches. These habitats are increasingly used by humans for recreation. The simple presence of people stresses parent plovers and may cause them to leave their nest. Once hatched, chicks may also feel threatened by human presence and thus may not search for and eat enough food to survive. People may step on the well camouflaged nests, leave garbage on the beach that attracts predators (foxes, gulls, racoons, skunks and crows) that will eat chicks and eggs, and unleash dogs which destroy nests and harass chicks. Vehicles, such as all-terrain vehicles, on beaches are particularly destructive since they destroy nests and chicks and frighten adults.

Oil and gas industry

Light pollution

Some birds, including Leach's Storm-Petrels, are attracted to light on ships or oil rigs. As a result, they may die from strikes (when they fly into these objects), become fouled with oil or be incinerated in open flares (Environment Canada 2001).

Oil spills

Oil may be discharged intentionally or released accidentally. Oil may enter the marine environment in large-scale spill events or small-scale chronic releases (Environment Canada 2001). In any case, the resulting oil slicks are very harmful to marine birds.

Oil can kill birds in several ways. Firstly, when oil comes into contact with a bird's plumage, the capacity of the plumage to waterproof and insulate is destroyed. For a bird floating in cold water this is a serious problem. Enough body heat can be lost through even a small spot of oil to result in hypothermia, the reduction of the bird's ability to feed and its eventual death. Oil has its second effect on birds when ingested. Oiled birds will attempt to preen themselves to restore their waterproofing, and in the process they ingest and inhale toxic oily compounds. As a result, birds slowly suffer from liver, lung, kidney and intestinal damage as well as damage to other internal organs (CWS 1992). The size of an oil spill is not always proportional to its consequences to seabirds since even a small slick can kill large numbers of birds if they are congregated in one area (Russell 2000, Environment Canada 2001).

The two main sources of oil on the sea surface are from shipping and oil and gas developments (Russell 2000). Discharges from these sources include discharges and accidental spills from oil and gas developments, oily bilge water discharge from ships, and accidental oil spills from vessels (CWS 1992, Environment Canada 2001).

Oil spills and their effect on marine birds are most often noted when dead or dying birds wash up on beaches; yet drift block experiments indicate that most birds oiled off the coast never in fact reach the shore (Russell 2000). Latest estimates from the CWS indicate that roughly 300 000 birds die each year off the coast of Newfoundland as a result of chronic oil pollution (Wiese and Robertson 2004). This figure is comparable to the impact of the Exxon Valdez spill each year. Hundreds of oiled birds were reported on Nova Scotia beaches in February 2002, in what could be the deadliest known act of illegal dumping in this region. The birds were likely oiled by bilge dumped from a passing ship trying to avoid port disposal fees (CBC News Online 2002).

Seismic exploration
Airguns detonated during seismic oil and gas exploration can have negative effects on marine birds (Environment Canada 2001). Diving birds such as Puffins, Razorbills, Guillemots, and Cormorants may be knocked out or killed by the strength of air gun shock waves detonated in their vicinity (Environment Canada 2001). Seismic activity may also indirectly impact marine birds since it can drive fish schools away from habitual fishing grounds.

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13 - Marine reptiles

Sea turtles are the only marine reptiles within Units 4, 5 and 6. Loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) sea turtles occur off the Atlantic Canadian coast, most often in the summer and fall (James 2001a). There are a few confirmed reports of Kemp's Ridley turtles (*Lepidochelys kempi*) (McAlpine et al. in press) and green turtles (*Chelonia mydas*) (James et al. in press), however, these species are not thought to be regular visitors to Atlantic Canada.

Leatherback turtle

Leatherback turtles are the largest of the sea turtles, often measuring over 1.7 m and weighing more than 454 kg (Boulon et al. 1996, Girondot and Fretey 1996). They have the most extensive geographic range of any marine turtle from 70ºN latitude (Gulliksen 1990) to 27ºS latitude (Boulon et al. 1988). In the western Atlantic, leatherbacks range as far south as Uruguay and Argentina (Pritchard and Trebbau 1984) and as far north as Newfoundland and Labrador (Bleakney 1965, Goff and Lien 1988).

Atlantic Canadian waters provide important seasonal foraging habitat for leatherback turtles that originate from tropical nesting areas including Costa Rica, Suriname and French Guiana (James 2004). As part of their seasonal migration, leatherback turtles occur off Atlantic Canada between May and November, with peaks during July to September (Bleakney 1965). Leatherback turtles can maintain body temperature, and therefore actively forage, in cold temperate waters (James and Mrosovsky 2004). Large leatherback sub-adults and adults migrate into Atlantic Canadian waters to feed on large species of jellyfish, including *Cyanea* sp. and *Aurelia* sp. (James and Herman 2001), although they also feed on salps and other gelatinous organisms. Regularly observed along continental shelf waters, leatherback turtles likely move from offshore waters into coastal areas to feed on seasonal proliferations of jellyfish (James 2001b). In Unit 6 leatherback turtles have been sighted off Marie Joseph and Ecum Secum, and in Unit 5 off Eastern Passage, Chebucto Head and in the approaches to Halifax Harbour (James pers. comm. 2003). Sightings have also been reported off Pennant Point and in St. Margarets Bay in Unit 4 (HRMWRCRMP, James pers. comm. 2003). Although leatherback turtles occur in Units 4-6 annually, there appears to be marked inter-annual variation in abundance in this area (James pers. comm. 2003). Satellite telemetry data and volunteered sightings suggest. that seasonal residency of leatherbacks along the Eastern Shore (Units 5 and 6) is relatively short, with turtles mainly occupying this area in early summer.

Loggerhead turtle

In the western Atlantic, the loggerhead turtle's range extends from Newfoundland to Argentina (OPR 2003). Fisheries observer data suggests this is the most abundant sea turtle species in eastern Canadian waters, with a distribution principally corresponding to warmer offshore waters. Loggerhead turtles are known to associate with convergence zones, drift lines and downwellings in the open ocean (Carr 1986). The distribution of loggerhead turtles is somewhat constrained by temperature; they are not often observed in waters below 15ºC (Davenport 1997).

Although less common in coastal areas along the Atlantic coast of Nova Scotia, there have been sightings of loggerhead turtles within Halifax Harbour and its approaches (Hebda pers. comm. 2003). An average adult measures 92 cm and weighs 115 kg (OPR 2003); loggerhead turtles found in Nova Scotia waters are typically large juveniles (Ryder pers. comm. 2003). They feed on molluscs, crustaceans, sponges, basket stars and fish (Mortimer 1995). Important nesting sites for this species occur along the southeast U.S. coast from Florida to North Carolina, one of which is the largest in the world (Ross 1985).

Threats to marine turtles

There are several threats to marine turtles off the Atlantic coast of Nova Scotia.

Entanglement in fishing gear

Leatherback turtles are sometimes incidentally entangled in lines and captured in fisheries nets. Compared to other Atlantic sea turtle species, leatherback turtles appear to be the most vulnerable to entanglement in fishing gear such as pelagic longlines, lines associated with fixed pot gear and gillnets, buoy anchor lines, and other ropes and cables (e.g., Chan et al. 1988, Goff and Lien 1988, Cheng and Chen 1997, Godley et al. 1998). On August 3, 2005 firecrews responding to a small brush fire on McNabs Island in Halifax Harbour rescued a large leatherback turtle that was caught up with ropes around her neck and flippers. The ropes were believed to be from lobster traps (CBC News online 2005). Entanglement of leatherback turtles in lines or cable may limit the turtles' ability to feed, dive, breathe or perform any other behaviour essential to survival, and can result in serious injuries, infection, necrosis or death (Balazs 1985).

Based on observer data, turtle interactions are well documented in Canadian pelagic longline fisheries targeting swordfish and tuna but do not appear to occur in longline fisheries targeting shark (Javitech 2003a). Although the majority of leatherback turtles are released alive from these fisheries, many have hooks and/or gangion lines attached when released. Post-release mortality is not known (Javitech 2002, 2003b, 2003c).

Although there is no observer information regarding interactions between leatherback turtles and fixed gear, information is available through strandings data. James and Martin (2003) reported 87 records of leatherback turtle strandings (i.e., either entangled in fixed fishing gear or found floating dead) in shelf waters off Atlantic Canada from 1995 to 2002. Seventy-four percent (74%) of these records provided direct or indirect evidence of leatherback turtles interacting with fixed fishing gear and 62% were associated with specific types of gears. Twenty nine percent (29%) of the records involved snow crab, rock crab, inshore lobster, offshore lobster and whelk fisheries whereas 22% involved mooring or buoy lines associated with bottom gill nets, bait nets and pound nets of other fish traps. Three percent were associated with vertical lines in the groundfish longline gear.

Marine debris

Leatherback sea turtles may be more susceptible to marine debris ingestion than other turtle species due to their pelagic existence and the tendency of floating debris to concentrate in convergence zones that adults and juveniles use for feeding areas and migration (Lutcavage et al. 1997, Shoop and Kenney 1992).

Leatherback turtles are known to ingest a range of anthropogenic marine debris such as plastic bags, plastic and styrofoam pieces, tar balls, balloons, plastic sheeting and fishing gear (e.g, Sadove 1980, Hartog and Nierop 1984, Balazs 1985, Lucas 1992, Starbird 2000). Even at low levels of ingestion, the turtles may choke or suffer complications with metabolism or gut function, which could lead to blockage of the digestive tract, potentially resulting in starvation or in the absorption of toxic byproducts (Plotkin and Amos 1989).

Noise

Little is known about the hearing ability of the leatherback turtle and its response to noise. However, studies involving adult green, loggerhead and Kemp's ridley turtles suggest that sea turtles are most sensitive to low frequency sound and can likely hear in the 250-700 Hz range (Ridgway et al. 1969, Lenhardt et al. 1983, Bartol et al. 1999).

Potential sources of anthropogenic noise in Atlantic Canadian waters that produce underwater sounds within the low frequency range detectable by sea turtles include oil and gas exploration and development, shipping, fishing, military activity, underwater detonations, and shore based activities (Greene and Moore 1995, Davis et al. 1998, Lawson et al. 2000).

Low frequency sounds may cause displacement of turtles from the area near the sound source and increased surfacing behaviour (O'Hara and Wilcox 1990, Lenhardt et al. 1983). Low frequency sound from certain sources may indirectly harm leatherbacks by displacing them from preferred foraging areas if they exhibit a flight response to the noise (e.g., O'Hara and Wilcox 1990, Moein et al. 1994).

Studies suggest that sea turtles may respond to seismic airgun noise in several ways, including avoidance manoeuvres (O'Hara and Wilcox 1990, Moein et al. 1994, McCauley et al. 2000), a temporary reduction in hearing capability (Moein et al. 1994), temporarily increased physiological parameters (e.g., glucose, white blood cells and creatinine phosphokinase) suggesting tissue damage or altered physiology (Moein et al. 1994), startle responses and erratic swimming behaviour (McCauley et al. 2000). Noise from vessel traffic and helicopter overflights may elicit a startle response in sea turtles (NRC 1990, NOAA 2002).

Collisions

Recreational boating and ship traffic may result in propeller and collision injuries to sea turtles. There are no reports of sea turtle collisions with boats in Atlantic Canada but they have been known to occur in some areas of the U.S. Propeller and collision-related injuries may represent a source of mortality, particularly in areas where commercial fishing, recreational boating and ship traffic are concentrated (NMFS 2002). Leatherback turtles may be vulnerable to collisions with marine traffic because they are known to bask for extended periods at the surface when foraging in temperate waters.

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14 - Marine mammals

Two groups of marine mammals inhabit the waters of SHACI Units 4-6: cetaceans (whales, dolphins and porpoises) and pinnipeds (seals). Several cetacean species forage in the coastal zone and are thought to move into bays and inlets while pursuing their prey. Seals are also found throughout the area, using rocky ledges and beaches for haulouts. In general, very little is known about the seasonal distribution or abundance of marine mammals of the Halifax Regional Municipality (HRM) coast. Gowans (pers. comm. 2001) reports that there are few ongoing studies on marine mammals between Halifax and Bay St. Lawrence on Cape Breton Island. Consequently, there are many unanswered questions about the use of this coast by marine mammals.

Cetaceans: Whales, dolphins and porpoises

Several cetacean species inhabit HRM coastal waters at some time during the year or periodically during their lifetime. These waters are also part of the migration pathway taken by humpback (*Megaptera novaeangliae*) and blue whales (*Balaenoptera musculus*) to the Gulf of St. Lawrence or points further north (Conway pers. comm. 2003). Other species forage, calve and use the area for other, as yet-unidentified, reasons (Gowans pers. comm. 2001, Whitehead pers. comm. 2001). Traditional ecological knowledge (HCESCRMP 1996, HRMWRCRMP 1996) and other sources (Katona et al. 1993, Conway pers. comm. 2003) have identified fin (*Balaenoptera physalus*), humpback, pilot (*Globicephala melaena*) and northern right whales (*Eubalaena glacialis*), as well as common dolphins (*Delphinus delphis*) and harbour porpoises (*Phocoena phocoena*) in the area. Various individuals, organizations and government agencies have reported sightings and strandings of other cetaceans within HRM waters (Table 14-1). Whale watch operators report that St. Margarets Bay, its surrounding waters, and the approaches to Halifax Harbour are regularly visited by minke whales (*Balaenoptera acutorostrata*), fin whales, harbour porpoises, white-beaked dolphins (*Lagenorhynchus albirostris*), and white-sided dolphins (*Lagenorhynchus acutus*). Blue whales, North Atlantic right whales and humpbacks are occasionally sighted in the same areas, humpbacks predominantly during the summer (Whitehead 1987, Butler pers. comm. 2001 and Gowans pers. comm. 2001). Of these animals, four are classified by COSEWIC – blue and North Atlantic right whales as endangered, and harbour porpoises and fin whales as special concern (COSEWIC 2004).

Table 14-1: Reported cetacean strandings in HRM coastal waters (compiled from Marine Animal Response Society 2003)

Species	Date	Location	Cause
Baleen whale	5-Oct-98	Seabright	Unknown
Pilot whale	28-Mar-99	Musquodoboit	Unknown
Fin whale	10-Oct-00	Dartmouth	Ship strike
Unidentified whale	23-Jul-01	Sutherland Island	Unknown
Minke whale	4-Sep-01	Clam Harbour Beach	Unknown
White-beaked dolphin	4-Aug-02	Halifax Harbour	Live-stranded
Harbour porpoise	5-Aug-02	Halifax Harbour	Unknown
Harbour porpoise	7-Aug-02	Halifax Harbour	Live-stranded
Minke whale	25-Aug-02	St. Margarets Bay	Unknown
Minke whale	4-Nov-02	Boutliers Point	Unknown

Whale watching

There are two major whale-watching areas in HRM coastal waters: St. Margarets Bay and Halifax Harbour, both located near the junction between SHACI Units 4 and 5. According to the HRM tourism web site (2003), these areas together support 17 whale-watching operations. The number and regularity of these whale-watching operations attests to a relatively high frequency of cetaceans on an ongoing basis.

Important cetacean areas

Information about cetacean habitat use in HRM coastal waters is sparse. Consequently it is difficult to interpret the importance of HRM coastal waters for cetaceans in a comprehensive manner. Two commonly used areas are identified but it is possible that other locations are of equal or greater importance. Lower human occupancy and use reduces the likelihood of incidental marine mammal observations in coastal areas north of the Halifax core area.

Peggy's Cove to Pearl Island

Perhaps the only studied areas in HRM coastal waters are outer St. Margarets Bay and immediate environs. Dalhousie University biology students have studied cetaceans in this area with cooperation from fishermen and whale watch operations, and it appears be particularly important for marine mammals. Cetaceans found here are thought to feed locally, especially on herring and mackerel, although no evidence has been collected to confirm their suspected preference for these prey species (Gowans pers. comm. 2001).

The mouth of St. Margarets Bay is important calving habitat for the white-beaked dolphin. Little is known about this species, except that it tends to arrive here in April and leave by June, as white-sided dolphins move in. This area is close to the southern limit of the white-beaked dolphin's distribution range, but it is not known where the animals go after June (Gowans pers. comm. 2001).

Approaches to Halifax Harbour (Chebucto Head, Sambro ledges)
Minke whales are seen off Chebucto Head year round, and fin whales are found during both summer and winter seasons (Whitehead pers. comm. 2001). There are at least two fin whale stocks on Canada's East coast: one summers off the Nova Scotia coast and winters further south; and the other winters off Nova Scotia and areas further south, and summers off Newfoundland. Both species feed on schools of herring while inhabiting these waters (Environment Canada 2003).

Seals (pinnipeds)

Two seal species are found along the HRM coast – harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). While seals spend most of their time in the water, they commonly haulout on rocks, ledges and beaches to rest, give birth and suckle their young. We know relatively little about seal habitat use within the HRM – there are no local studies of pinnipeds in the area. The last visual survey was conducted prior to 1991 (Bowen pers. comm. 2001, Conway pers. comm. 2002, Stobo pers. comm. 2003), however, satellite tagging of grey seals since 1995 has provided new insight into the spatial distribution of this species on the Scotian Shelf (Bowen et al. in press).

Harbour seals are found in Nova Scotian waters year-round, feeding on Atlantic herring, cod, pollock, short-finned squid, as well as mackerel and capelin (P. Lane and Associates 1992, Katona et al. 1993). They are non-migratory, coastal, and generally found in small, evidently isolated populations (Boulva and McLaren 1979). European studies indicate that they typically stay in relatively small home areas up to a maximum of 50 km in diameter (Thompson et al. 1994). Harbour seals are widespread and increasing, common along the islet-rich coasts of HRM (P. Lane and Associates 1992, Davis and Browne 1996). Traditional ecological knowledge has identified dozens of seal haulouts throughout the HRM, roughly equitably from St. Margarets Bay all the way up to Liscomb Harbour (Figures 12-1a to 12-1h in Marine Associated Birds section). Past studies on harbour seal diets found reliably high populations at Ecum Secum and other points further north (Boulva and McLaren 1979, Bowen and Harrison 1996). Although the abundance of seals in this area is unknown, P. Lane and Associates (1992) suggests that approximately 1/3 more harbour seals are found along the Atlantic Coast north of Halifax compared to areas to its south, in accordance with Boulva and McLaren (1979). Pupping areas are not well known along this coast (Bowen pers. comm. 2001).

Grey seals used to be less common along the coast than harbour seals, and tend to use more exposed haulout sites, but a continued increase in their numbers has changed this in recent years. Like harbour seals, they feed on a variety of benthic and pelagic fishes but diets tend to vary both geographically and seasonally (Bowen et al. 1993). Their primary breeding site is Sable Island, with fewer adults and juveniles seen as the mainland is approached (Bowen et al. 2003). One grey seal rookery was found at Green Island, off Ecum Secum, but it may not be occupied every year as rookeries vary in size and occasionally change locations between years (Conway pers. comm. 2002). Although inshore areas are likely more important for juveniles, adults congregate within them at selected breeding grounds in large numbers and subsequently disperse over a broad range (Bowen pers. comm. 2001). Grey seals found along the Nova Scotia coast in winter could be visiting from Sable Island or from the ice covered Gulf of St. Lawrence. Conway (pers. comm. 2003) reports that grey seals regularly occupy the Hens and Chickens rocks off Point

Pleasant Park in Halifax Harbour between January and March, although in recent years they have been seen in this area year round (Bowen pers. comm. 2004).

Threats to marine mammals

Several activities pose potential threats to marine mammals inhabiting SHACI Units 4-6.

Chemical pollution of water bodies and prey species

The pollution of coastal waters through land-based sources (including pesticides, fungicides, herbicides and other biocidal agents), pseudo-estrogenic compounds, heavy metals and other substances may cause significant problems in coastal waters, especially in and around industrial harbours such as Halifax. No local research has attempted to identify or quantify these threats but ecotoxicological studies underway at the Marine Environmental Research Institute in mid-coastal Maine may yield some relevant insights (MERI 2003).

Coastal development

Coastal development may cause problems to seals by disturbing or displacing preferred pupping areas. The HRM coast is undergoing sustained coastal development due to ongoing growth and foreign coastal land acquisition. Small, localized changes in coastal areas may cumulatively amount to significant consequences to coastal seal populations.

Finfish aquaculture

Penned fish attract seals, which are usually shot if they occur in small numbers (Bowen pers. comm. 2001).

The fishing industry

Marine mammals (particularly cetaceans) may become entangled in fishing nets, buoys and other types of gear. The depletion of prey availability, either directly or indirectly by the fishing industry may cause a problem for local cetaceans (Gowans pers. comm. 2001).

Military activities

Military training activities involving sonar and pressure waves from explosions can harm cetaceans. It is not known if these activities occur within inshore waters.

Oil and gas activities

There are several potentially harmful impacts to marine mammals associated with oil and gas exploration and production activities (seismic exploration, operational discharges, drilling, oil spills and related boat and helicopter traffic).

Noise

According to Hammill and others (2001), oil and gas exploration can have detrimental effects on certain marine mammal species, primarily through the noise this activity generates. Noise is a problem because marine mammals emit or hear sounds in the same frequency range as those caused by airguns, drilling activities, ships and helicopters. The potential impacts of ship and helicopter noises are outlined below, and many of these concerns mirror those associated with seismic survey and drilling noises. Specifically, Odontocetes and Pinnipeds have shown strong avoidance reactions to seismic surveys (Richardson et al. 1995).

Operational discharges

During exploratory, development and production phases, different kinds of drilling muds and formation cuttings containing toxic compounds are routinely released into the ocean. The biological effects of such discharges would most likely be short term and at small distances from the point source. Nonetheless, distant impacts could result, including the diversion of marine mammal migration routes or the routes of their fish prey (Boudreau et al. 2001).

Oil spills and blowouts

During exploration, development and production phases, there is a risk of an oil spill or blowout. Both events would release potentially large amounts of oil and/or gas into the ocean, thus contaminating the marine environment. The various potential effects of these events are outlined by Boudreau et al. (2001).

Vessel traffic

The underwater sounds emitted from shipping, industrial, military, fishing, and whale watching vessels may all have impacts on marine mammals. Air traffic over water (helicopters, low flying planes) may also have detrimental effects.

Noise

Marine vessels are a major contributor to overall background noise in the sea. Noise is a concern because:

1) Increases in background noises from anthropogenic sources may prevent the detection of other sounds important to marine mammals. This could interfere with navigation and communication.
2) Certain sounds may disturb behaviour. Reactions could range from a brief interruption of normal activities (resting, feeding, disruption of mother-pup bond, and other social interactions) to a longer term displacement from the noisy area.

3) Some sounds could cause temporary or permanent reductions in hearing sensitivity.
4) Noise could disrupt the distribution of prey items and thus disrupt feeding patterns (Richardson et al. 1995).

Collisions
Marine vessels may unintentionally strike marine mammals leading to injury and/or death (H. Whitehead pers. comm. 2001, S. Gowans pers. comm. 2001).

Whale watching

Whale watching may become problematic if operators specifically seek or approach whales. Excessive whale watching (high numbers of vessels at once or continuous watching over several hours) can disturb whales, disrupt their natural behaviour and lead to vessel collisions (Gowans pers. comm 2001, Whitehead pers. comm. 2001).

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15 - Species at risk

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was initiated in 1977. COSEWIC evaluates the status of wildlife (flora and fauna) in Canada and produces a yearly national listing of Canadian species at risk. Each listed species is designated a status (Table 15-1).

Table 15-1: COSEWIC status definitions for species at risk (COSEWIC 2003a)

Species	Any indigenous species, subspecies, variety or geographically or genetically distinct population of wild fauna and flora.
Extinct	A species that no longer exists.
Extirpated	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species likely to become endangered if limiting factors are not reversed.
Special concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at risk	A species that has been evaluated and found to be not at risk.
Data deficient	A species for which there is insufficient scientific information to support status designation.

Prior to the passing of the *Species at Risk Act* (SARA) in June 2003, COSEWIC designations had no legal standing. COSEWIC, acting as an advisory body to government, relies on the SARA to confer legal standing on the species listed by COSEWIC (Government of Canada 2004). COSEWIC chooses the species to be evaluated based on nominations by government and external experts. Species listed by COSEWIC do not represent all the species at risk in Canada. Although many species have been evaluated (e.g., almost all cetaceans found off eastern Canada), many others, such as marine fish and invertebrates, have received less attention (Breeze et al. 2002). The Minister of Environment has 90 days to respond to COSEWIC's recommended status (Government of Canada 2004). The federal Cabinet then has nine months to decide whether the species should be added to the legal list.

The SARA was established to prevent threatened or endangered wildlife from becoming extinct and species of special concern from becoming endangered or threatened (Government of Canada 2004). The SARA is also intended to help in the recovery of these species. Although provisions of the SARA took effect on June 5th, 2003, several provisions, such as the establishment of prohibitions against killing listed species or destroying their critical habitat, did not come into force until June 2004. Species listed under SARA and found in Units 4, 5 and 6 are the leatherback turtle and the Atlantic, spotted and northern wolffish.

In Canada, several provinces, including Nova Scotia, have legislation to protect rare and endangered species. Some species may be listed by COSEWIC and provincial legislation. Some COSEWIC listed species are also ranked by the United States federal government and listed under the U.S. *Endangered Species Act*. Similarly, some COSEWIC listed species may also be protected under international agreements such as the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

Fourteen species in Units 4, 5 and 6 are listed by COSEWIC as species at risk (COSEWIC 2003a) (Table 15-2). Of these fourteen species, ten are currently protected under SARA.

Table 15-2: COSEWIC listed species in Units 4, 5 or 6 (compiled from COSEWIC 2003a and Environment Canada 2002)

Species common name	Latin name
Endangered	
*Blue whale	*Balaenoptera musculus*
*Leatherback turtle	*Dermochelys coriacea*
*North Atlantic right whale	*Eubalaena glacialis*
*Piping Plover	*Charadrius melodus melodus*
*Roseate Tern	*Sterna dougallii*
Threatened	
Cusk	*Brosme brosme*
*Least Bittern	Ixobrychus exilis
*Northern wolffish	*Anarhichas denticulatus*
*Spotted wolffish	*Anarhichas minor*
Special concern	
Atlantic cod (Maritimes population)	*Gadus morhua*
*Atlantic wolffish	*Anarhichas lupus*
Fin whale	*Balaenoptera physalus*
Harbour porpoise	*Phocoena phocoena*
*Harlequin Duck	*Histrionicus histrionicus*

*Currently protected under SARA

Note: The Western North Atlantic humpback whale (*Megaptera novaeangliae*) population was delisted as of May 2003 and is no longer considered at risk.

Endangered species

Five species found within Units 4, 5 or 6 are ranked as endangered by COSEWIC: the blue whale (*Balaenoptera musculus*), leatherback turtle (*Dermochelys coriacea*), North Atlantic right whale (*Eubalaena glacialis*), Piping Plover (*Charadrius melodus*) and Roseate Tern (*Sterna dougallii*).

Blue whale

Blue whales, the largest of the baleen whales, are rarely observed. Generally found alone or in groups of two or three, they are distributed widely in the world's oceans, primarily along the edges of continental shelves and in the open ocean but can also be found inshore (Yochem and Leatherwood 1985). Blue whales are seen along the Atlantic coast of Nova Scotia during their migration between the Gulf of St. Lawrence and the eastern U.S. coast, from late June or early July through October (Conway pers. comm. 2003).

Blue whales were significantly reduced in number by whaling and are now protected by the International Whaling Commission (Yochem and Leatherwood 1985). In 1983, the blue whale was considered a single unit by COSEWIC and designated special concern (COSEWIC 2003a). In 2002, the species was split into two populations, Atlantic and Pacific, and both were designated endangered. This species is listed as endangered by CITES (UNEP-WCMC 2003), to which Canada is a signatory, and is designated endangered under the U.S. *Endangered Species*

Act (USFWS 2003). For more information on the blue whale, refer to the Marine Mammals section of this document.

Leatherback turtle

The leatherback turtle is undergoing a severe worldwide decline (COSEWIC 2001). Threats include entanglement in fishing gear (NMFS 1992, Goff and Lien 1988), often resulting in serious injury or drowning, and ingestion of marine debris such as plastic bags (Hartog and Van Nierop 1984) and fishing gear (Starbird 2000) that can block the digestive tract and lead to starvation (Plotkin and Amos 1990). The leatherback turtle was initially designated endangered by COSEWIC in 1981 and retains that status (COSEWIC 2003a). This species is listed as critically endangered by the CITES (UNEP-WCMC 2003). In 1996, the leatherback turtle was designated endangered under New Brunswick's *Endangered Species Act* (Environment Canada 2003a). In the United States, the leatherback is designated endangered by the *Endangered Species Act* (USFWS 2003). Many countries have laws to protect the leatherback turtle, however, enforcement of this protection is difficult in many areas. Abundance estimates of leatherback turtles in Atlantic Canada are not available (James 2001), however, it is estimated that there are at least several hundred thousand animals in the Atlantic population (Sinclair 2004). For more information about the leatherback turtle, see the Marine Reptiles section of this document.

North Atlantic right whale

The North Atlantic right whale is one of the most critically endangered marine mammals in the world (Right Whale Recovery Team 2000). In Canada, the known distribution of right whales includes four areas, namely, the lower Bay of Fundy, innerbank basins on the Scotian Shelf (Roseway and Emerald Basins), the northwestern Gulf of St. Lawrence, and coastal waters of eastern and southern Newfoundland (Right Whale Recovery Team 2000), although there have been sightings of right whales in Halifax Harbour (Gowans pers. comm. 2003).

Initially considered a single species, the right whale was designated endangered in 1980 (COSEWIC 2003a). In May 2003, the population was split into two species to allow a separate designation of the North Atlantic right whale. This species was designated endangered in 2003. Heavily reduced by whaling, the current population of this species, found only in the North Atlantic, is approximately 322 animals, 220-240 of which are adults (COSEWIC 2003b). High mortality within the population is caused by ship strikes and entanglement in fishing gear. The population has been decreasing over the last decade. The right whale is listed as endangered by the CITES (UNEP-WCMC 2003) and is designated endangered under the U.S. *Endangered Species Act* (USFWS 2003). For more information on the right whale, refer to the Marine Mammals section of this document.

Piping Plover

The melodus subspecies of the Piping Plover is a small migratory shorebird that breeds only in North America along the Atlantic coast from Newfoundland to South Carolina. Surveys indicate there were approximately 481 adult Piping Plovers in the Atlantic Provinces in 2001 (Ferland and Haig 2002), far below the goal of 670 adults set by the recovery team (Environment Canada 2003b). In 2001, forty five breeding pairs were counted in a census in Nova Scotia (Ferland and Haig 2002). In SHACI Units 4-6, nesting sites at Clam Harbour Beach, Martinique Beach, Conrod's Beach and Cole Harbour have been identified (Lock et al. 1994, HCESCRMP 1996). However, a Piping Plover breeding census in 2001 indicated that in SHACI Units 4-6, Piping Plovers were found only on Martinique Beach (one breeding pair, three adults) (Ferland and Haig 2002). Piping Plovers nest on exposed sandy or gravel beaches above the normal high-water mark. Plovers depend on beaches for nesting and foraging.

Loss of habitat caused by human use of beaches and disturbance of nesting sites is the greatest threat to Piping Plovers (Environment Canada 2003b). Predation of eggs and chicks by crows, gulls, foxes, and feral dogs and cats is another limiting factor. Water level changes caused by seasonal storms and spring tides can threaten nesting efforts.

In Canada, the Piping Plover is protected under the federal *Migratory Birds Convention Act* of 1917 (Department of Justice Canada 2003) and under the corresponding *Migratory Bird Treaty Act* in the United States. Provincially the plover is protected by endangered species legislation in Quebec, New Brunswick and Nova Scotia (Environment Canada 2003b). Endangered species legislation recently passed in Newfoundland and the *Wildlife Conservation Act* recently passed in Prince Edward Island will eventually provide added protection for plovers. The Piping Plover is designated threatened under the U.S. *Endangered Species Act* (USFWS 2003). For more information on the Piping Plover, see the Marine Birds section of this report.

Roseate Tern

Roseate Terns are seabirds that breed on both sides of the Atlantic Ocean and winter along the northern coast of South America (Environment Canada 2003c). Canada represents the northern limit of the Roseate Tern's range, where it breeds along the Atlantic coast in Nova Scotia and in Quebec, and has been seen in New Brunswick and in Newfoundland. Roseate Terns typically nest on small offshore islands and islets along the Atlantic coast of Nova Scotia.

Although the overall population of Roseate Terns in northeastern North America has been increasing slowly since 1987, the Canadian population, which represents about 3-4% of the northeastern total, has remained stable since 1985. In Canada, there were an estimated 150 pairs of Roseate Terns counted in 2000 (Environment Canada 2003c). In Nova Scotia, three large colonies (Brothers Islands, Grassy Island, and the Country Island complex) account for about 94% of the Canadian population. There are known nesting sites in SHACI Unit 4 on Sambro Island, Wedge Island, MacDonald's Point, Fisherman's Beach in SHACI Unit 5 and Western Bird Island in SHACI Unit 6 (Environment Canada 2003c).

Roseate Terns were hunted extensively for their eggs and feathers that were sold to the millinery industry (Environment Canada 2003c). The main limiting factor for this species is human exploitation on wintering grounds. Predation by gulls, crows, short-eared owls and other wildlife also pose a threat to eggs and young at breeding colonies and may be the primary reason for the selection of islands and islets as nesting sites (Environment Canada 2003c, NSDNR 2002). Other limiting factors include competition from other birds for nest sites, toxic chemicals passed through the food chain with subsequent effects on reproduction (thinning of eggshells and reduced reproductive success) (Environment Canada 2003c) and coastal development (NSDNR 2002).

In Canada, the Roseate Tern is protected under the *Migratory Birds Convention Act* of 1917 (Department of Justice Canada 2003), and in the United States under the corresponding *Migratory Bird Treaty Act*. Under the Nova Scotia *Endangered Species Act* this species is designated endangered. It is also protected under the U.S. *Endangered Species Act* and is designated threatened along the Atlantic coast (USFWS 2003). The Roseate Tern is not protected on its wintering grounds. For more information on the Roseate Tern, see the Marine Birds section of this report.

Threatened species

Four species found within Units 4, 5 or 6 are ranked as threatened by COSEWIC: cusk (*Brosme brosme*), Least Bittern (*Ixobrychus exilis*), northern wolffish (*Anarhichas denticulatus*) and spotted wolffish (*Anarhichas minor*)

Cusk

Cusk are solitary, slow swimming fish found mainly on the southwestern Scotian Shelf and slope and in the Fundian Channel (DFO 1998). They prefer a rock, gravel and occasionally mud bottom and seldom move from bank to bank. The main population of cusk occurs in the Gulf of Maine/southeastern Scotian Shelf and has been declining since 1970 (COSEWIC 2003b). Summer research survey vessels indicate a significant decline of cusk in recent years with an apparent population collapse in 1992 (DFO 1998). Unrestricted fishing for this large, slow growing, bottom-dwelling fish may have contributed to its decline. Although fishing for this species has been capped since 1999, it is still a source of mortality (COSEWIC 2003b). Cusk were designated threatened by COSEWIC in 2003 (COSEWIC 2003a). Although cusk have been known to occur in coastal areas along the Atlantic coast of Nova Scotia, there is little information on abundance, distribution and whether they are permanent residents of this area (Comeau pers. comm. 2003).

Least Bittern

The Least Bittern, a small member of the heron and bittern family, breeds from southern Canada south to South America and winters from California, Texas and Florida to Panama and Colombia (Environment Canada 2003d). The Least Bittern has been observed in all provinces in Canada, except Prince Edward Island. Nesting in Nova Scotia occurs occasionally with the majority occurring in southern Ontario, Manitoba, Quebec and New Brunswick. In Units 4, 5 and 6 the Least Bittern is found in Prospect and Musquodoboit.

In Canada, the Least Bittern population is likely declining slowly, although reliable survey methods to estimate population trends have yet to be developed (Environment Canada 2003d). The Canadian population of Least Bitterns is estimated at less than 1000 pairs, the majority of which are found in Ontario (Environment Canada 2003d). Least Bitterns nest in freshwater marshes. Subsequently, loss of habitat resulting from the drainage of wetlands is the main reason for the decline in their numbers. Natural filling in of wetlands by woody vegetation is also responsible for habitat loss. Human disturbance during the nesting period such as recreational water boat usage which creates high waves is a second important limiting factor.

The Least Bittern is considered threatened in Canada (COSEWIC 2003a). It is also protected in Canada under the *Migratory Birds Convention Act* (Department of Justice Canada 2003), and in the United States under the corresponding *Migratory Bird Treaty Act*. It is protected under several provincial wildlife acts. The Least Bittern is protected in Mexico under the Migratory Bird Treaty between the United States and Mexico but it is not protected south of Mexico where some of its wintering grounds are found. For more information on the Least Bittern, see the Marine Birds section of this report.

Northern wolffish and spotted wolffish

In Canada, the northern wolffish and spotted wolffish occur primarily off northeast Newfoundland. They inhabit cold waters (below 5ºC) on the continental shelf (Environment Canada 2003e, f). It is not known whether specific areas of importance within Units 4, 5 and 6 exist for these species.

Numbers of northern wolffish and spotted wolffish in the western Atlantic and the number of their locations have declined dramatically in the last 20 years (Environment Canada 2003e, f). Although these fish are not targeted by the fishing industry, they are taken accidentally by offshore trawlers. Another threat is the damaging of spawning habitat by bottom trawling for fish and dredging for scallops and clams (Environment Canada 2003e, f). Northern and spotted wolffish are protected under the federal *Species at Risk Act* and there is potential for some protection under the Habitat section of the Canadian *Fisheries Act*. A combined recovery strategy for both species is being developed.

Species of special concern

Five species found within Units 4, 5 or 6 are ranked as special concern by COSEWIC: Atlantic cod (*Gadus morhua*)(Maritimes population), Atlantic wolffish (*Anarhichas lupus*), fin whale (*Balaenoptera physalus*), harbour porpoise (*Phocoena phocoena*) and Harlequin Duck (*Histrionicus histrionicus*).

Atlantic cod (Maritimes population)

Atlantic cod has been the dominant commercial species of the Northwest Atlantic where they occur from inshore shallow water areas of approximately 5 m to the edge of the continental shelf and a depth of 600 m (DFO 2003a). Local inshore populations of cod exist along the Nova Scotia coast in Units 4, 5 and 6 such as the Halifax group that occurs within the approaches to Halifax Harbour (Fanning pers. comm. 2003). This group is found in the inshore area from early fall to early winter and migrates to deeper water offshore during winter (Fanning pers. comm. 2003, DFO 2003b).

Although stocks of the southern Gulf of St. Lawrence, Gulf of Maine and Scotian Shelf are all at low levels of abundance, those on the eastern Scotian Shelf are at historic lows and have continued to decline despite the closure of the directed fishery in September 1993 (COSEWIC 2003b, DFO 2003b).

In 1998, cod was considered a single unit and assigned a status of special concern in Canada (COSEWIC 2003b). In 2003, the stocks were split into separate populations and the Atlantic cod Maritimes population was designated special concern. Although the directed fishery for cod has been under moratorium since 1993, there are no indications that stock recovery is occurring (DFO 2003b). Atlantic cod is sensitive to human activities and is threatened by accidental catch in other fisheries, natural predation, and natural and fishing-induced changes to the ecosystem (COSEWIC 2003b).

Atlantic wolffish

Atlantic wolffish are solitary, bottom-dwelling fish. In the Northwest Atlantic, they occur on the continental shelf and in deeper slope waters from southern Labrador to Cape Hatteras (DFO 2002). In the Maritimes, wolffish are most numerous in the approaches to the Bay of Fundy, Browns, Roseway and LaHave Banks, the northeastern portion of the Scotian Shelf adjacent to the Laurentian Channel and in the waters off western Newfoundland. They are usually found at depths between 50 and 150 m but have been recorded between 1 and 550 m (DFO 2002). Seasonal inshore migrations are thought to occur in the spring when mature fish are found in shallow waters of 0 to 15 m. Relatively large numbers of wolffish occur close to shore in the late summer and fall in areas in Units 4, 5 and 6 (DFO 2002).

Data suggest that Atlantic wolffish numbers in Canadian waters have declined by 87% from the late 1970s to the mid 1990s (Environment Canada 2003g). Despite the decline, it is thought that the wolffish is still widespread and exists in relatively large numbers, although it is found in fewer locations and the range where it is abundant may be shrinking. There are no data available on the direct causes of the declines in the Atlantic. The Atlantic wolffish, once a targeted species in a commercial fishery, is now only caught accidentally in fisheries for other species. There are no mechanisms in place to protect this species. The Atlantic wolffish is designated special concern by COSEWIC (2003a).

Fin whale

Fin whales are migratory baleen whales that spend winters on breeding grounds in deeper offshore waters and migrate closer inshore to feed in the summer (Walker et al. 1992, Agler et al.1993). On Canada's east coast, there are at least two stocks of fin whales: one summers off the coast of Nova Scotia and winters further south; the second stock summers off the coast of Newfoundland and winters off the coast of Nova Scotia and further south (Environment Canada 2003h). Fin whales are commonly sighted in the summer in the Gulf of Maine, Bay of Fundy (Agler et al. 1990), and the Gulf of St. Lawrence (Edds and MacFarlane 1986). Along the Atlantic coast of Nova Scotia, fin whales are generally sited a few times each year in St. Margarets Bay and its surrounding waters and the approaches to Halifax Harbour, more commonly in the winter and occasionally in summer (Gowans pers. comm. 2003). Within the St. Margarets Bay area in Unit 4, fin whales prefer the deeper waters to the east (Eddy 2001). Fin whales feed predominantly on herring (Gowans pers. comm. 2003, Woodley and Gaskin 1996) but also on euphausiids, copepods (Meredith and Campbell 1988) and other schooling fish. The presence of prey appears to be the main factor in the distribution and abundance of the fin whale (Woodley and Gaskin 1996).

In 1987, the fin whale was designated special concern in Canada (COSEWIC 2003a). The main reason for the decline of fin whale populations was whaling. On the east coast of Canada and the United States, fin whales were the target of land-based whaling operations (Mitchell 1974). The International Whaling Commission now protects fin whales via a moratorium on the hunting of fin whales. Since the cessation of whaling, populations seem to be recovering (Environment 2003h). Limiting factors for the fin whale include chemical pollution that causes debilitation and death, and the depletion of capelin stocks, an important prey of the fin whale during migration. This species is listed as endangered in the Convention on International Trade in Endangered Species of Wild Flora and Fauna (UNEP-WCMC 2003) and is designated endangered by the U.S. *Endangered Species Act* (USFWS 2003). For more information on the fin whale, see the Marine Mammals section of this report.

Harbour porpoise

The Northwest Atlantic harbour porpoise is widely distributed and inhabits bays, oceanic canals and harbours, preferring water temperatures of 5 to 16 °C and areas with a great deal of turbulence or changes of current (Environment Canada 2003i). Harbour porpoises can be divided into three populations that summer in the Gulf of Maine/Bay of Fundy, the Gulf of St. Lawrence and Newfoundland-Labrador. The 2003 COSEWIC status report on the northwest Atlantic harbour porpoise indicates that the Bay of Fundy/Gulf of Maine population is transboundary in nature (COSEWIC 2003c).

They are observed year round along the Atlantic coast of Nova Scotia (Gowans pers. comm. 2003). Although they are distributed throughout coastal waters between Blandford and Betty's Island (Unit 4), in this area they seem to prefer the shallower waters off Blandford near St. Margarets Bay (Gowans pers. comm. 2003, Eddy 2001) and are sighted more frequently in early summer (Eddy 2001).

One of the biggest threats to this species is incidental capture in fishing gear, especially gillnets (COSEWIC 2003b, Environment Canada 2003i). Initially designated as threatened in Canada in 1990, the harbour porpoise was downlisted to special concern in 2003 (COSEWIC 2003b). Reduced fishing activities in the Atlantic and measures to reduce incidental catches in the Bay of Fundy have helped lower the number of porpoises killed accidentally. However, potential incidental catch levels remain a concern. Since 1982, the harbour porpoise has been protected under Canada's *Fisheries Act*. This species is listed as vulnerable by the CITES (UNEP-WCMC 2003). Although this species was proposed for listing as threatened under the U.S. *Endangered Species Act*, in 1999, U.S. National Marine Fisheries Service determined that the proposed listing was not warranted because bycatch reduction programs implemented in Canada and the U.S. were sufficient to ensure the population's sustainability. In 2001, the U.S. government published its intention to remove this population from the candidate list under the *Endangered Species Act* (COSEWIC 2003c). For more information on the Harbour porpoise, refer to the Marine Mammals section of this document.

Harlequin Duck

The Harlequin Duck is a small, subarctic marine duck. Four populations of the Harlequin Duck are found worldwide, one of which is the eastern population along the Atlantic Coast. The eastern population, once estimated at 5000-10 000 birds, declined to fewer than 1500 birds (Environment Canada 2003j). Over the last few years, numbers have increased to approximately 1800 individuals (Environment Canada 2003j). The majority of the eastern population breeds along eastern Hudson Bay although a few breed inland on the north shore of the Gulf of St. Lawrence and on the shore of the Gaspé peninsula. About half the population winters in New England. Many Harlequin Ducks winter on the east and south coasts of Newfoundland; the north shore of the Gulf of St. Lawrence; in Nova Scotia, New Brunswick and Maine; and in a few areas south of Cape Cod (Environment Canada 2003j).

In the winter, the Harlequin Duck occurs along headlands, feeding close to rocky shorelines or rock skerries. It is during the winter that Harlequins Ducks are observed in Units 4, 5 and 6 (Butler pers. comm. 2003). In SHACI Units 4-6, Prospect and the Eastern Shore Islands Wildlife Management Area are known wintering sites for the Harlequin Duck. Surveys counts in 2002 indicate that there were 57 Harlequin Ducks at Prospect and 355 in the ESIWMA (Boyne pers. comm. 2005).

Harlequin Ducks breed along fast-flowing rivers in the spring and spend the rest of the year in coastal marine environments. The main factors that have contributed to their decline are destruction, alteration (such as hydro projects) and contamination (e.g., oil spills) of their habitat (Environment Canada 2003j). Under the *Migratory Birds Convention Act*, the Harlequin Duck is classified as a game bird and is managed by the Migratory Game Bird Hunting Regulations (Department of Justice Canada 2003). For the protection of this bird, the hunting season for Harlequin Ducks in the Atlantic provinces has been closed since 1990-91 and is also closed in Maine. In Nova Scotia and New Brunswick, the Harlequin Duck is designated endangered under the respective provincial *Endangered Species Acts* (NSDNR 2002). Designated endangered in Canada in 1990, the Harlequin Duck was downlisted to special concern in 2001 (COSEWIC

2003a). For more information on the Harlequin Duck, refer to the Marine Birds section of this document.

Extinct

Four species that were once likely found in Units 4, 5 and 6 are now extinct.

Sea mink

The sea mink (*Mustela macrodon*), a marine rocky seacoast carnivore, once ranged from Maine to Nova Scotia. After being intensively hunted for its fur, it became extinct in 1894 and is no longer found in Atlantic coastal waters (COSEWIC 2003a). COSEWIC designated the sea mink extinct in 1986.

Labrador Duck

The Labrador Duck (*Camptorhynchus labradorius*), formerly a regular visitor along Nova Scotia's coast (Tufts 1986), is believed to have gone extinct in 1875.

Eelgrass limpet

The eelgrass limpet (*Lottia alveus*), a marine invertebrate, became extinct in 1929 (COSEWIC 2003a). It lived on the blades of North Atlantic eelgrass near open coastal waters. In the 1930s, the loss of eelgrass beds, wiped out by disease, led to the extinction of the limpet in Nova Scotia (Davis and Browne 1996). The eelgrass limpet is the only recorded case of a marine invertebrate species extinction in the North Atlantic.

Great Auk

The Great Auk, a flightless bird, bred along both coasts of the North Atlantic Ocean. In Canada, it was found in Newfoundland, on the Magdalen Islands, in New Brunswick and in Nova Scotia (Environment Canada 2003k). It inhabited coastal waters and nested on rocky coasts and islets in large colonies. Clumsy and vulnerable, the Great Auk was hunted extensively for its feathers and for food. This species is believed to be extinct since 1844.

Extirpated

Two species once presumably found in Units 4, 5 and 6 have been extirpated from the Northwest Atlantic.

Grey whale

The grey whale (*Eschrichtius robustus*) was extirpated from the Atlantic Ocean before the end of the 1800s (COSEWIC 2003a).

Atlantic walrus

The Northwest Atlantic population of the Atlantic walrus (*Odobenus rosmarus rosmarus*) became extirpated by the mid 19th century (COSEWIC 2003a). Commercial hunting for this marine mammal has greatly reduced its range that formerly extended as far south as Nova Scotia and Massachusetts. In Canada, the Atlantic walrus is still found in Arctic waters from the polar ice-sheet in the Arctic Ocean to the Bering Sea, James Bay and the Labrador coast (Environment Canada 2003l).

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16 - Marine bioinvaders

Marine bioinvasions have received increased attention in recent years and yet the term "invasive" has no standard meaning and is often interpreted in various ways. Thus defining an alien invasive species is difficult. There are two broad categories of alien species. The first category includes alien species that escape from human control, go beyond intended physical boundaries and cause environmental damage (CBD 2000). These invasive processes present major challenges to regulatory regimes. The second category includes alien species that remain under human control but damage native ecosystems. The resulting damage is linked to species being alien but not to invasiveness, and can generally be addressed through conventional land-use and environmental management regulations and incentives (CBD 2000).

The IUCN (2000) provides the following definition for an invasive species which excludes those described in the second category: "Invasive species means an alien species which becomes established in natural or semi-natural ecosystems or habitats, is an agent of change, and threatens native biological diversity" (IUCN 2000). This section addresses invasive species that have an environmental impact and/or threaten native biological diversity.

There continues to be much debate about the point at which an alien species may be termed "invasive". This may be best addressed by describing the sequence of events from introduction to actual invasion. Introduction means that the alien species has been transported by humans across a major geographical barrier (CBD 2000). An unintentionally introduced alien species or an intentionally introduced species that spreads beyond the areas of human control may die out within a brief period of time, establish itself for a time and then die out, or remain in the area in which it was first introduced without disrupting local biota or ecosystems (CBD 2000). Invasion may be said to occur when alien species not only persist but proliferate and spread beyond defined limits.

Marine biological invasions may occur in various ways. Mechanisms of introduction of non-indigenous marine organisms to North American waters include the unintentional release of marine organisms from the ballast water of vessels (Carleton 1992) and aquaculture operations; and the intentional dumping of species imported for the aquarium industry and the release of target species for fisheries or aesthetic purposes (Gibson et al. 2001).

On the northeast coast of North America, shipping is the single most important vector of introduced species, accounting for over 76% of marine biological invasions (Fofonoff et al. 2002). Compared to some other areas, the Atlantic provinces are particularly susceptible to introductions of new species through ballast water because commercial shipping to the Atlantic provinces typically involves large ships, many of which carry ballast, and thus many opportunities for dispersal of alien, and potentially invasive, species (Smith and Kerr 1992).

The concern about the introduction of species into areas where they did not previously exist is related to the impacts that bioinvaders may have on the new environment. Marine biological invasions can lead to biodiversity reduction, ecosystem alteration, and economic impacts such as fisheries declines and direct impacts on mariculture activities (Hewitt 2002).

There has been no comprehensive survey of the distribution of most biological invaders in Atlantic Canada or Nova Scotia. Information available about local marine bioinvasions is presented in Table 16-1 and elaborated upon below.

Table 16-1: Known marine and estuarine biological invasions in Units 4, 5 & 6

Species	Origin	Known distribution in Units 4, 5 & 6	Source/Vectors in Atlantic Canada	Documented effects*
Codium fragile ssp. *tomentosoides* (Oyster thief)	Japan	St. Margarets Bay, Peggy's Cove	Cultured oysters Ships' hulls Packaging materials for shellfish products	Replaces kelp and eelgrass beds Displaces native species dependent on the beds
Furcellaria lumbricalis		Sparingly along the Atlantic coast of Nova Scotia		Competes with and causes declines in populations of *Chondrus crispus* (Irish Moss)
Fucus serratus	Europe		Probably rocks used as ship's ballast	Competes with local species (e.g., *Fucus evanescens*)
Carcinus maenas (Green crab)	Europe	Atlantic coast		Competes with and contributes to declines in native crab populations Contributes to declines in native soft-shelled clam populations
Littorina littorea (Common periwinkle)	Europe	Intertidal zones along Atlantic coast	Either intentionally released as food source or accidentally released (ballast stone)	Changes sediment accretion and community composition through 'bulldozing' activity
Convoluta convoluta	Europe	Duncan's Cove, Terrance Bay, Cranberry Cove, off Blandford	Possibly ballast water or fouled ships	
Botryllus schlosseri	Europe	Ship Harbour		Kills juvenile oysters by restricting their access to flowing water
Ciona intestinalis		Eastern portion of St. Margarets Bay	Ballast water Transfer of aquaculture products	Competes for food and space of mussels

Table 16-1 cont'd: Known marine and estuarine biological invasions in Units 4, 5 & 6

Species	Origin	Known distribution in Units 4, 5 & 6	Source/Vectors in Atlantic Canada	Documented effects*
Salmo salar (Atlantic salmon)		Possible scattered occurrences in areas of salmon aquaculture facilities	Escapes from sea pens or rearing facilities	Threatens genetic integrity and survival of local salmonid populations
Membranipora membranacea (bryozoan)	Europe	St. Margarets Bay, Peggy's Cove	Ballast water or ship fouling	Causes defoliation of native kelp beds by encrusting kelp fronds and rendering them brittle Decreases available grazing spaces for *Lacuna vincta*

*Some of these effects have been documented elsewhere and are not necessarily the same on the Atlantic coast. Compiled from: AANS no date, Chase et al. no date, Bertness 1984, Bird et al. 1991, Carleton 1992, Lambert et al. 1992, Chavanich and Harris 1999, Rivest et al. 1999, Theriault 2001, Boutilier 2002, Cameron et al. 2002, Chapman et al. 2002, Graham et al. 2002, Mallet 2002, Novaczek 2002, Ricciardi 2002, Whitlow 2002, Whoriskey 2002, Chapman pers. comm. 2003, Clancy pers. comm. 2003, Clancy and Hinton 2003, MITSGCCR 2003

Marine plants

The green alga, *Codium fragile* ssp. *tomentosoides*, is a potent biological invader native to Japan that has colonized coastal areas around the world (Chapman et al. 2002). Although the vectors of transport of *Codium* to North America are not known, the most probable means of dispersal is attachment on ships' hulls or on the shells of oysters shipped from Europe (Carlton and Scanlon 1985). This alga spread to the eastern United States and was first found along the western Atlantic coast in New York in 1957 (Chase et al. no date). Since then it has spread rampantly and is found as far south as South Carolina (R. Wiseman pers. comm. to A.S. Chapman 2002) and as far north as Nova Scotia. Within 10 years of its discovery in Mahone Bay, it had spread over 1200 km to areas in northern Nova Scotia, New Brunswick and Prince Edward Island (PEI) (Hubbard and Garbary 2002). Within Unit 4 it is found in Peggy's Cove and St. Margarets Bay (Theriault 2001). In Nova Scotia, it is abundant in intertidal pools but is particularly dominant in the shallow subtidal zone where it can grow to 1 m in length (Chapman 1999). In areas where it occurs it is often the dominant species among the algae of the intertidal zone. *Codium* plants can replace entire kelp beds by forming continuous meadows. They can also replace native eelgrass beds, displacing other native species dependent on the beds, such as economically important oysters (Chase et al. no date).

Furcellaria lumbricalis, an aggressive alga invader, was first recorded in 1829 from the islands of St. Pierre and Miquelon (Novaczek 2002). By 1933 it was found on PEI and along the Northumberland Strait, and since then in Newfoundland and sparingly along the Atlantic coast of Nova Scotia (Bird et al. 1991). *F. lumbricalis* competes with and causes declines in populations of *Chondrus crispus* (Irish moss). This effect, coupled with a less efficient harvest of Irish moss because of the mix of species (i.e., the usable is intermixed with the unusable *Furcellaria* (Chapman pers. comm. 2003), has resulted in the decline of the Irish moss industry in PEI.

Fucus serratus , the toothed wrack is a robust, olive-brown shrubby seaweed. *Fucus serratus* was introduced from Europe and found in the Gulf of St. Lawrence in 1869, likely introduced via rocks used as ship's ballast (Novaczek 2002). It expanded its range and in 1933 its distribution included Miramichi in New Brunswick, PEI, western Cape Breton and Ingonish, Nova Scotia. In 1948 it was found in Yarmouth, Nova Scotia and by 1972 it had reached the Bras d'Or Lakes and was encircling Cape Breton. The population in Yarmouth expanded and another population developed near Lunenburg. *F. serratus* competes with the local alga species, *F. evanescens*.

Marine invertebrates

Littorina littorea, the common periwinkle, was introduced from Europe and colonized the Atlantic coast from Nova Scotia to New Jersey in the 30 year period between 1860 and 1890 (Carleton 1992). Now one of the most prevalent molluscs of the Atlantic rocky shore (Carleton 1992), it can be found between Labrador and Virginia, preferring hard surfaces, estuarine waters and intertidal to subtidal zones (MITSGCCR 2003). Introduced to Canada intentionally for food or through ballast water, no other invasive marine mollusk in North America has had a greater ecological impact; the common periwinkle has affected many animal and plants species by altering their abundance, distribution and diversity on rocky and soft bottom shores (Carleton 1992).

The green crab, *Carcinus maenas*, is an invasive species from Europe. Since its introduction to Chesapeake Bay in 1879, the green crab has spread northward (Davis et al. 2002). It was first reported in eastern Canadian waters in St. Andrews, New Brunswick in 1951 (Cameron et al. 2002). It continued to spread throughout the Bay of Fundy and reached Lower Argyle in southeastern Nova Scotia by 1956. It had entered Unit 4 by the 1970s when it reached St. Margarets Bay. By the 1990s it had reached Port Hawkesbury on Cape Breton Island. Since then it has become established in the southwestern Gulf of St. Lawrence, around the periphery of Cape Breton Island, in the Northumberland Strait and on PEI. The green crab has been found along soft and hard surfaces in intertidal and subtidal regions (MITSGCCR 2003).

The European flatworm, *Convoluta convoluta*, has invaded the western North Atlantic Ocean (Rivest et al. 1999). First observed on *Codium* near Halifax in 1995, it now occurs in large numbers as far south as Massachusetts (Rivest et al. 1999). Although a detailed description of its distribution along the coast of Nova Scotia does not exist, it has been found in Duncan's Cove, Terrance Bay, Cranberry Cove and off Blandford, typically on rocky shores in the shallow subtidal zone down to 10 m (Chapman pers. comm. 2003). Possibly introduced by ballast water or ship fouling, its impacts are unknown (Rivest et al. 1999).

Urochordates

Invasive tunicates such as *Ciona intestinalis* and *Botryllus schlosserii* have become a growing concern for the shellfish industry in Nova Scotia. Conditions under which mussels are grown in aquaculture also allow growth of fouling tunicates (Mallet 2002). Tunicates can have significant impacts on hanging cultures of mussels, oysters and scallops (AANS no date). They can compete with mussels for food and can add enough weight to the lines, causing cultured mussels to fall off and become prey to crabs and starfish. Tunicates can overgrow mussels and nets, affecting the commercial yield of the cultured shellfish.

The solitary tunicate, *Ciona intestinalis*, is found on several mussel farms in Nova Scotia, particularly in the South Shore (AANS no date). Known areas of infestation of *C. intestinalis* in the province are the Lobster Bay area in southwestern Nova Scotia, St. Margarets Bay (Unit 4), Mahone Bay, and two small areas on the northern and southern portions of Isle Madame in Cape Breton (Clancey and Hinton 2003). In St. Margarets Bay, a light infestation is found along the eastern portion.

The colonial tunicate, *Botryllus schlosseri*, was introduced from Europe and is found from Newfoundland to Chesapeake Bay (MITSGCCR 2003). In Nova Scotia, it is found on oysters farms and is known to affect juvenile oysters (AANS no date). This tunicate covers the oysters and kills them by restricting their access to the flowing water they require for respiration and feeding. *B. schlosseri* is found in Ship Harbour and likely occurs in other locations in the province (Clancey pers. comm. 2003).

Fish

Cultured Atlantic salmon (*Salmo salar*) can escape from sea cages into local rivers. It poses a threat to wild Atlantic salmon populations that are at risk of biological extinctions (Whoriskey 2002). Wild Atlantic salmon populations have adapted genetically to conditions in their home rivers and are thus river specific. Cultured Atlantic salmon come from a small group of rivers, some of them of European origin. The escape of cultured salmon into local rivers threatens genetic integrity and survival of the wild salmon populations. Distributions of wild salmon may have declined by almost 50% following invasions of non-native salmon (Graham et al. 2002). Cultured salmon are possibly scattered in areas of salmon aquaculture facilities.

Bryozoans

Membranipora membranacea, a white bryozoan, was transported to the Northwest Atlantic coast from Europe, likely by ship fouling and ballast water (Theriault 2001). It first appeared on the Atlantic coast of North America at the Isle of Shoals in the Gulf of Maine on the kelp Laminaria saccharina in 1987 (Lambert et al.1992). Since then it has spread along the coast, south to New York (Chase et al. no date) and north to Nova Scotia (Theriault 2001), where it was first reported from Mahone Bay in 1992 (Scheibling et al. 1992). The exact distribution of M. membranacea in Nova Scotia is unknown but in Unit 4 it is found in St. Margarets Bay and Peggy's Cove (Theriault 2001). This bryozoan encrusts algae, making them brittle and more prone to breakage. In some areas, this has resulted in the loss of entire kelp beds. This is of concern because kelp provides habitat and food for several marine species. Where the kelp bed has been devastated by

M. membranacea, Codium is free to establish itself, preventing the kelp from growing back (Theriault 2001). Together, these two bioinvaders may cause long-lasting changes to Nova Scotia's subtidal ecosystem with potential negative effects on biodiversity and commercial resource use.

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Coastal industries

17 - Fishery

SHACI Units 4, 5 and 6 lie within the NAFO 4W and 4X fishing divisions. Within these divisions, the inshore NAFO units that roughly correspond to the study area of this report are 4Wk and 4Xm. Both of these units extend beyond the limits of Halifax County, and beyond the 12 nm SHACI study boundary (Figure 17-1). The majority of landings data discussed here are commercial landings data from DFO's Zonal Interchange File (ZIF) accessed through the DFO Marine Fish Division Virtual Data Centre in March 2005, henceforth cited as ZIF (2005). For some species, landings data are available from within SHACI Units 4, 5 and 6. For those cases where landings data are not available for a species within SHACI Units 4-6, landings are discussed in terms of NAFO divisions 4Wk and 4Xm. The reader is cautioned, however, that landings from the NAFO divisions may not necessarily be a good indication of the extent of fisheries within SHACI Units 4-6.

There are active invertebrate, groundfish and pelagic fisheries in 4Wk and 4Xm. Total average landings between 1995 and 2002 were greater east of Halifax in 4Wk than in 4Xm located southwest of Halifax (Tables 17-1 and 17-2).

Table 17-1: Invertebrate, groundfish and pelagic fish landings in NAFO unit 4Wk (1995-2002) (based on data from ZIF 2005)

Landings (t)*	1995	1996	1997	1998	1999	2000	2001	2002
Invertebrates	1049	917	774	776	984	1087	1015	1020
Groundfish	427	4053	3196	4372	3311	2444	2046	2031
Pelagic fish	447	11 109	10 584	4557	8373	3920	4 65	9379
Totals	1923	16 079	14 554	9705	12 668	7451	7226	12 430

* landings are to nearest tonne

Table 17-2: Invertebrate, groundfish and pelagic fish landings in NAFO unit 4Xm (1995-2002) (based on data from ZIF 2005)

Landings (t)*	1995	1996	1997	1998	1999	2000	2001	2002
Invertebrates	768	621	704	992	1166	1095	1226	1026
Groundfish	2200	1951	2127	1736	5012	2947	1274	916
Pelagic fish	4754	3447	3979	2234	3398	2999	1545	1085
Totals	7722	6019	6810	4962	9576	7041	4045	3027

*landings are to nearest tonne

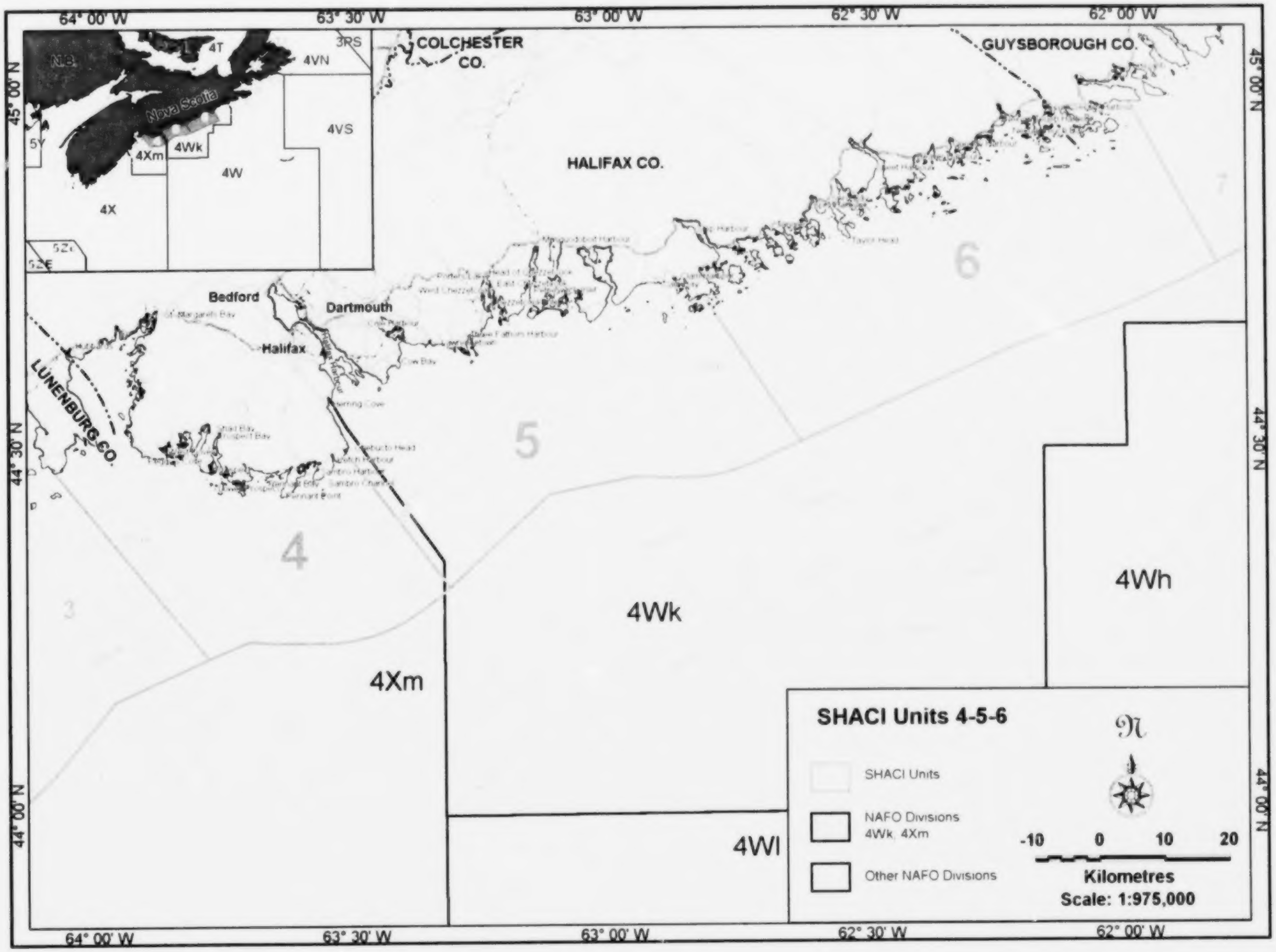

Figure 17-1: SHACI Units 4, 5 and 6, NAFO Units 4Xm and 4Wk boundaries, and Halifax County lines. Inset map of Atlantic Coast NAFO Divisions. Basemap layers (NSGC).

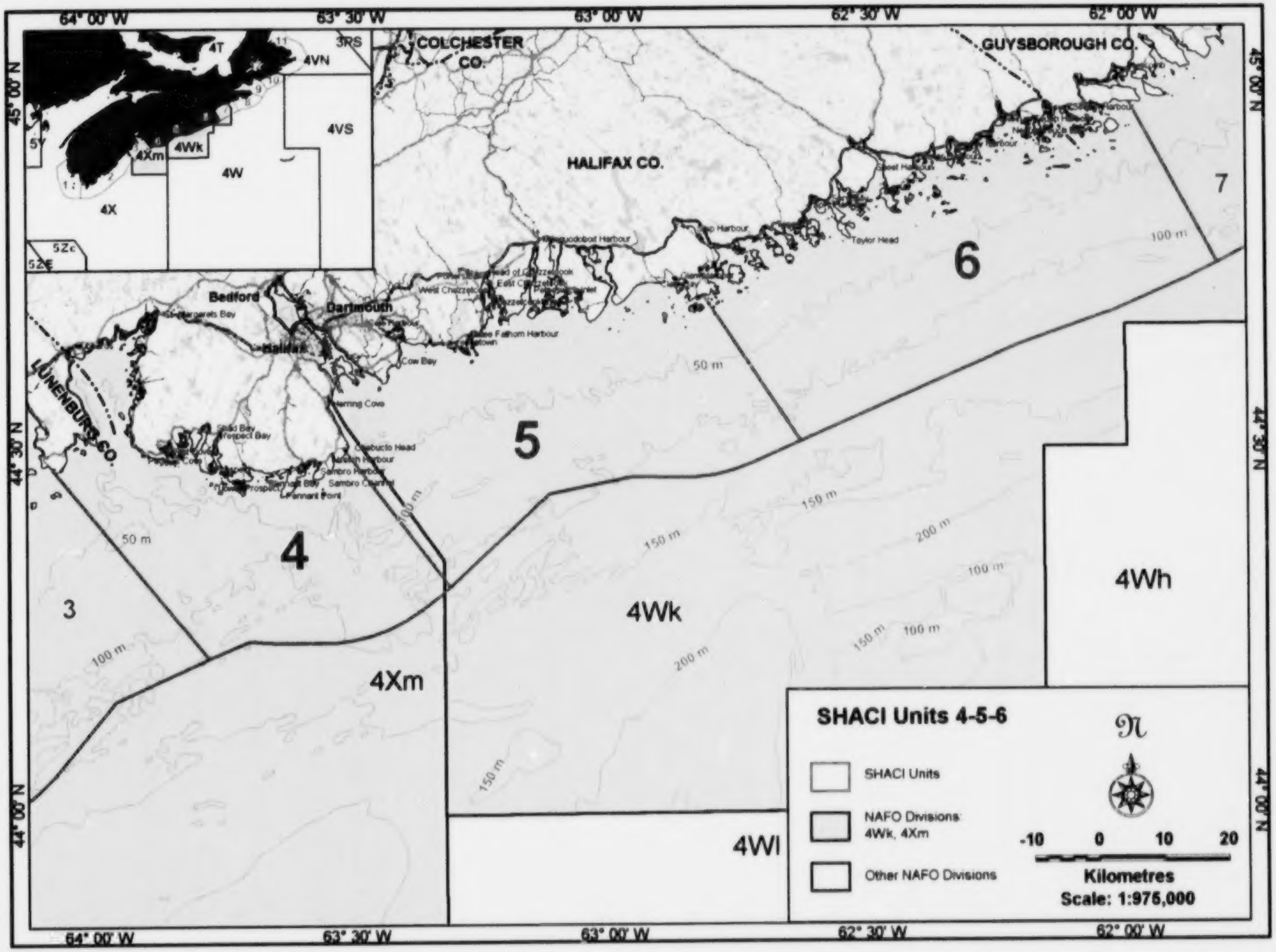

Figure 17-1: SHACI Units 4, 5 and 6, NAFO Units 4Xm and 4Wk boundaries, and Halifax County lines. Inset map of Atlantic Coast NAFO Divisions. Basemap layers (NSGC).

Invertebrates

Several invertebrate species are harvested in NAFO divisions 4Wk and 4Xm, including Jonah crab, lobster, mussel, sea urchin, rock crab, scallop, shrimp, snow crab (queen), soft shell clam, squid and whelk (Tables 17-3 and 17-4). Small landings of quahog and Stimpson's surf clams were made in 4Xm in 2002, however total yearly landings were not available for the preparation of this report.

Invertebrate landings in 4Wk averaged at 936 t between 1995 and 2002 (Table 3). Landings declined between 1995 and 1997, and then increased to eventually peak at 1087 t in 2000. The main species fished in this area include lobster and soft shell clam. Until 1998, sea urchins also made up a substantial proportion of the catch. Snow crab have made up increasingly larger portions of total landings since that time.

Table 17-3: Invertebrate landings (t)* in NAFO unit 4Wk (1995-2002) (based on data from ZIF 2005)

Species	1995	1996	1997	1998	1999	2000	2001	2002
Lobster	319	303	319	413	431	639	556	474
Sea urchin	428	450	345	246	0	12	0	-
Soft shell clam	294	160	86	68	318	152	0	30
Snow crab (queen)	0	0	0	6	83	261	418	459
Rock crab	5	3	23	44	21	16	21	15
Jonah crab	0	0	0	0	0	5	15	42
Shrimp	3	0	0	0	0	0	0	-
Squid	0	0	1	0	0	2	1	1
Scallop	0	1	0	0	0	0	0	1
Total	1049	917	774	777	853	1087	1011	1022

*landings are to nearest tonne

Table 17-4: Invertebrate landings (t)* in NAFO unit 4Xm (1995-2002) (based on data from ZIF 2005)

Species	1995	1996	1997	1998	1999	2000	2001	2002
Lobster	611	612	676	803	931	806	747	582
Snow crab (queen)	0	2	0	51	84	129	302	292
Jonah crab	2	1	19	107	112	141	121	124
Sea urchin	155	1	3	0	0	0	0	-
Shrimp	0	0	2	26	13	14	19	6
Rock crab	0	5	5	5	4	2	7	5
Scallop	0	0	0	0	0	0	25	1
Soft shell clam	0	0	0	0	18	0	2	7
Squid	0	0	0	0	0	3	1	0
Unspecified crab	0	0	0	0	2	0	1	1
Totals	768	621	705	992	1164	1095	1225	1018

*landings are to nearest tonne

In 4Xm, invertebrate landings increased steadily after 1996, with the exception of a small decrease in 2000, and peaked in 2001 at 1225 t (Table 17-4). Lobster made up the greatest percentage of total landings, accounting for 76% of total invertebrate landings between 1995 and 2002. Since 1998, snow crab and Jonah crab have made up substantial proportions of total invertebrate landings. There was a small sea urchin fishery in this area, but the only substantial landings reported were in 1995.

Lobster

Fishing areas

Lobster in SHACI Units 4, 5 and 6 are mainly found within Lobster Fishing Area (LFA) 32, and in small portions of LFAs 31B and 33 (Figure 17-2). These LFAs extend well beyond the boundaries of the SHACI study area. Although a major fishery in the area, lobster landings in SHACI Units 4, 5 and 6 are small compared to the major lobster producing areas in southwest Nova Scotia and Sydney Bight. There are 771 lobster licenses in LFA 33, 166 in LFA 32 and 149 in LFA 31. The trap limit in all areas is 250 traps (DFO 1998a).

Landings

Lobster landings vary along the Atlantic coast of Nova Scotia from year to year and from area to area. In the mid 1970s to early 1980s, landings in LFA 31, 32 and 33 were the lowest in recorded history for these areas. Landings in these areas then peaked around 1990. Since then, recorded landings have declined by roughly 60, 30 and 40% in LFAs 31, 32 and 33 respectively (DFO 1998a). These fluctuations in lobster populations demonstrate the habitat's capacity to support a large stock, but also the vulnerability of the stock to collapse. DFO (1998a) suggests that without management change, landings could return to the low and variable landings. According to DFO (1998a), recorded lobster landings in the early 1990s underestimate actual landings by 15, 18 and 29% in LFAs 31, 32 and 33 respectively.

Landings within NAFO units 4Wk and 4Xm are also considered. Landings are greater in 4Xm (Table 17-4), which includes Unit 4, than in 4Wk (17- 3), which includes Units 5 and 6. In 4Wk, between 1995 and 2002, lobster landings averaged 432 t and peaked at 639 t in 2000. In 4Xm, lobster landings increased between 1995 and 1999 to peak at 931 t. Landings have since decreased slightly and, between 1995 and 2002, averaged 721 t (ZIF 2005).

Regulations

There have been regulations associated with the inshore lobster fishery since 1873. Under current regulations, there are no new licenses issued, it is a trap only fishery, there is no sport fishery, there are set trap limits and fishing seasons, minimum size limits are imposed, and there is a prohibition against retaining berried females (DFO 1998a).

Baited traps, or pots, are used to catch lobster. As of 1998, there was a 250 trap limit in LFAs 31B, 32 and 33. The fishing season in LFA 31B and 32 was from April 19 to June 20 and the minimum carapace size was 82.5 mm. In LFA 33, the season went from the last Monday in November until May 31, and the minimum carapace size was 81 mm (DFO 1998a).

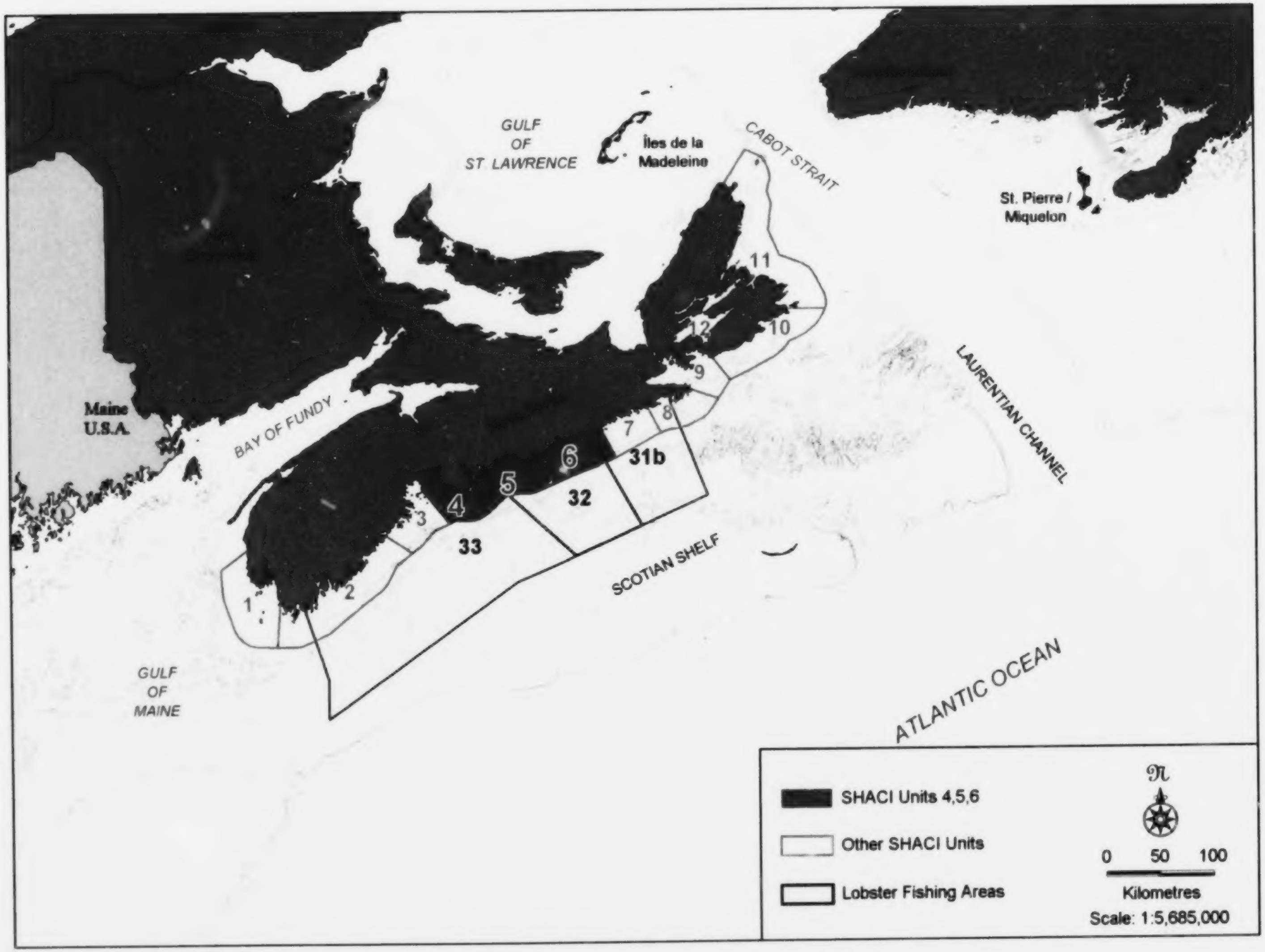

Figure 17-2: Lobster fishing areas (LFAs) 31B, 32, 33 (DFO). Basemap layers (NRCan).

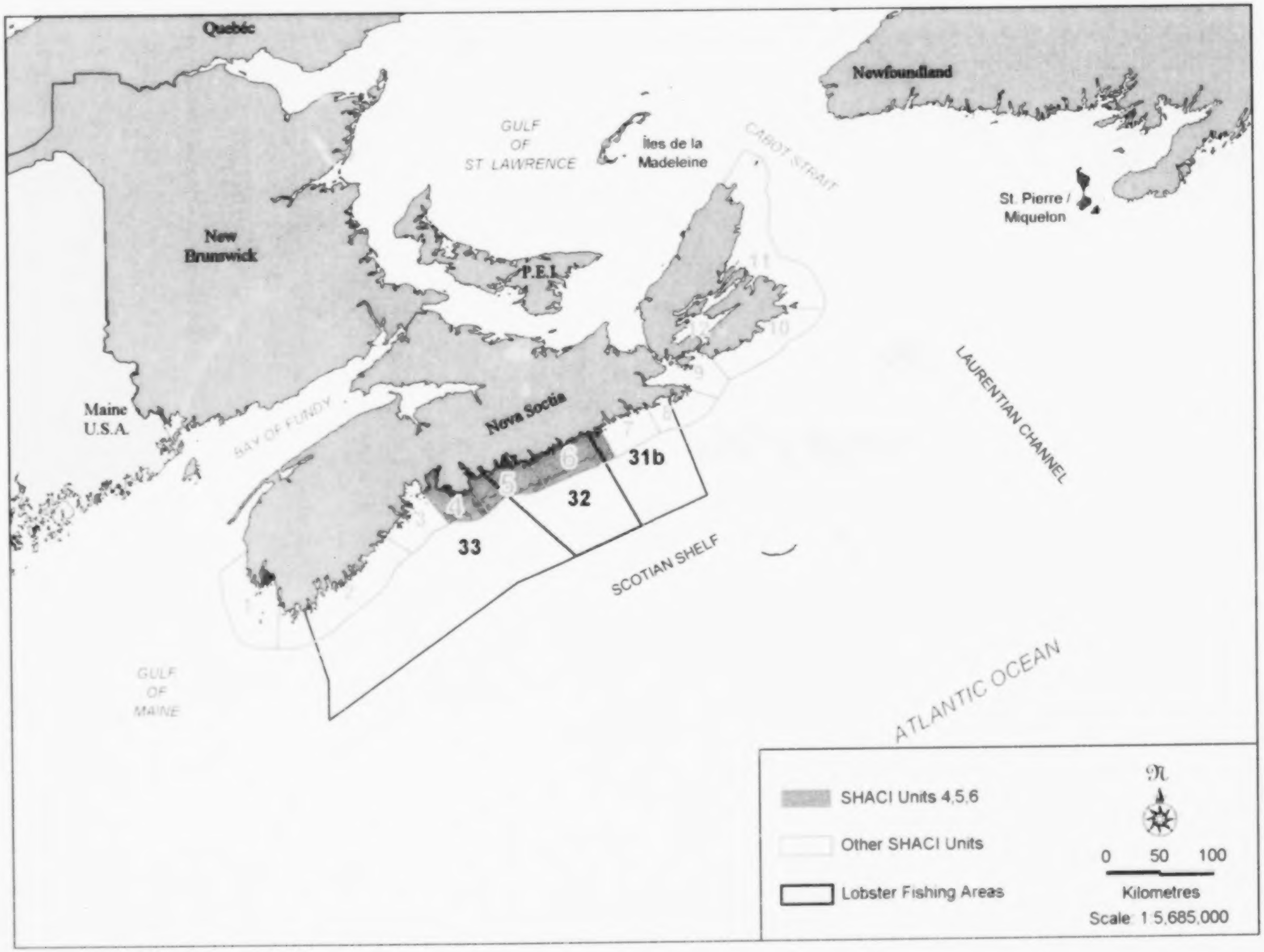

Figure 17-2: Lobster fishing areas (LFAs) 31B, 32, 33 (DFO). Basemap layers (NRCan).

Soft shell clam

Based on archaeological records, the soft shell clam fishery has existed in the Maritimes for at least two to three thousand years. Currently, both recreational and commercial soft shell clam harvesting occurs in areas of SHACI Units 4, 5 and 6 (DFO 1996).

Formal catch records for soft shell clams began in the later 1800s, and the harvesting technology has changed little since that time. There were few restrictions on this fishery until minimum shell length limits were instituted in the 1970s, and in the mid 1990s when commercial harvesters were required to have licenses. As of 1996, recreational harvesting still required no permit. In 1995, statistical district 20, the majority of which lies in Unit 5, was the most productive Atlantic coast district for Nova Scotia soft shell clams (Figure 17-3) (DFO 1996).

Landings

Soft shell clams make up an important part of the invertebrate fishery in SHACI Units 4, 5 and 6, particularly in NAFO unit 4Wk located east of Halifax (Table 17-3). Soft shell clams are harvested throughout the year using rakes and tongs. In 4Wk, soft shell clam landings fluctuated between 1995 and 2002, the average landings over this time being 139 t. Peak landings occurred in 1999 at 318 t and the lowest reported landings of 0.2 t were reported in 2001. The soft shell clam fishery is much smaller in NAFO unit 4Xm, located west of Halifax (Table 17-4). In this area, average landings since 1995 were only 3.4 t (ZIF 2005).

Fishing areas

Soft shell clam inhabit muddy intertidal habitats but also live subtidally in a variety of sediment types. Clam beds in statistical district 20 have a higher standing stock (Mullen and Woo 1995) and are more productive than other areas in Nova Scotia (DFO 1996). In 1995, Atlantic coast statistical district 20 (near Halifax) was the most productive, holding 202 (22%) of all licenses and reporting 239 t (59%) of total landings. At this time, half of all harvesters in district 20 dug clams as their sole means of income (DFO 1996).

Ingalls (1942) surveyed clam producing flats in Nova Scotia in 1941 and 1942. Areas within SHACI Units 4, 5 and 6 highlighted by Ingalls (1942) include Clam Harbour, Musquodoboit, Petpeswick, Chezzetcook, and Indian Harbour. No flats of commercial importance were located between Halifax and Liverpool (Ingalls 1942). Mullen and Woo (1985) later assessed clam stocks in Clam Harbour and Three Fathom Harbour. At the time, these two areas were used by full-time commercial fishermen as well as local and tourist diggers who dug clams for their personal use. In this area, harvesting occurred from late February until early fall (Mullen and Woo 1985).

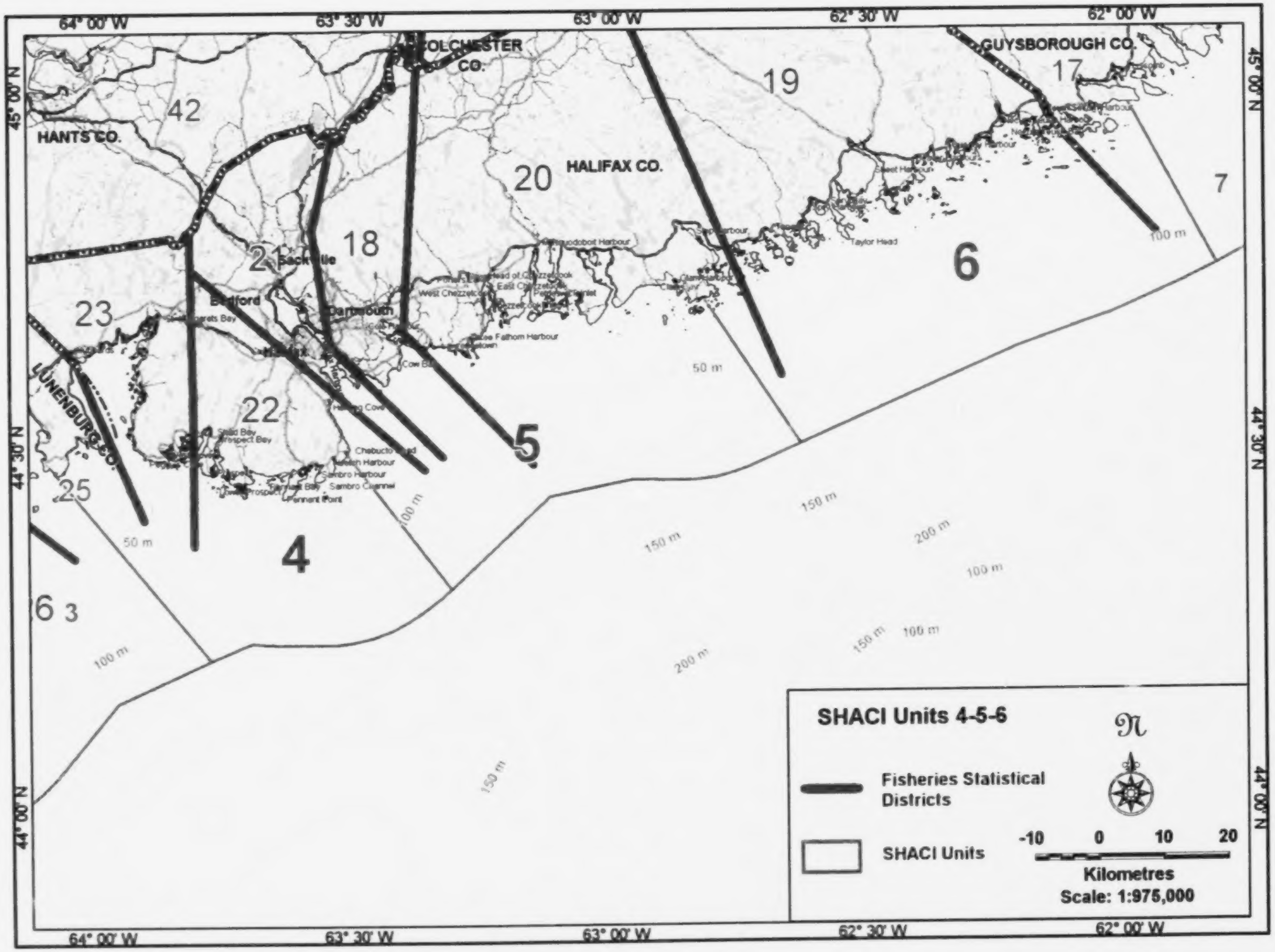

Figure 17-3: Fisheries Stastistical Districts (DFO). Basemap layers (NSGC).

Clam Harbour

In the early 1940s, Clam Harbour was described as 80 ha of sandy flat entirely suited to clam production, most of which was exposed at any low tide. The eastern and middle sections of the Harbour were crowded with small clams, and in the west side and Indian Cove near the mouth of the Harbour (where public fishing was confined) a square foot of flat yielded roughly four to seven marketable clams. The largest clams were found along the sides of the channels running through the flats (Ingalls 1942). According to Ingalls (1942) clam flats also existed outside and eastward of Clam Harbour. Mullen and Woo (1985) found that Clam Harbour was able to support higher levels of fishing than it was experiencing.

Three Fathom Harbour

In 1985, the Three Fathom Harbour clam flat was 11 ha in size. As with Clam Harbour, Mullen and Woo (1985) found that Three Fathom Harbour was able to support higher levels of fishing than it was experiencing.

Musquodoboit Harbour

Ingalls (1942) described Musquodoboit Harbour as a vast area of at least 405 ha of sand flat. Unlike the Clam Harbour flats, most of the Musquodoboit Harbour flats were only exposed on full tides. The main clam flats in this area were between Goose Head and Baker's Island, outside Baker's Island, between Baker's Island and Indian Head, and around Indian Head in Butneygum. Butneygum, the largest single flat in the area, was extremely isolated and could only be accessed by boat. Clams of all sizes were found in Musquodoboit Harbour but without a uniform distribution. In 1942, this area was deemed good for a public fishery and leasing purposes (Ingalls 1942).

Petpeswick

Only three sections of Petpeswick Harbour were considered suitable for clam production in 1942. One area located above the Narrows comprised roughly 6-8 ha, supported a good public fishery and had an abundance of small clams of all sizes. Another larger flat was located below this area and contained a higher percentage of marketable clams, but fewer small ones. This flat was gradually decreasing in size due to encroaching shifting sands. The third area was roughly 10 ha in size and located in a cove near the mouth of the Harbour on the east side (Ingalls 1942). This area was heavily used in the early 1940s and local harvesters were anxious to reserve an area for local use and/or to set management practices to prevent the clam resource from becoming completely exhausted (Ingalls 1942).

Chezzetcook

Ingalls (1942) reported a large sand flat roughly 2.6 km square at Black Point, near the mouth of Chezzetcook Harbour. At the time, this flat had an abundant, yet uneven, distribution of small clams. Two similar, but smaller flats were located further up the Harbour to the east of the islands. Even in the early 1940s, Chezzetcook clam beds were depleted to the extent that local diggers went elsewhere to dig commercially (Ingalls 1942).

Indian Harbour
Located near Clam Harbour, Indian Harbour had roughly 10 ha of clam flats in the early 1940s. Two thirds of the flat consisted of sand, and the other third consisted of very soft mud. Small clams were found densely in the sandy areas, while larger clams were found more sparsely near the channel (Ingalls 1942).

Management issues
The soft shell clam resource along the Atlantic coast of Nova Scotia is declining in several historically productive beds. Clam habitat, and thus the fishery, is under pressure in several ways. First, there are more people harvesting clams. Between 1994 and 1995 the numbers of commercial licenses issued along the Atlantic coast of Nova Scotia rose from 551 to 905. This increase was likely due to jobs disappearing from the traditional fisheries. Despite this increase in effort, the reported landings decreased in 1995. Another issue is the close of productive, yet contaminated beds. Problems also occur in some beds between local harvesters and harvesters from distant parts of the province (DFO 1996). As a result of these pressures, DFO (1996) estimates that fishing pressure on open beds is likely too high and recommends the development of community-based programs to advise and assist in the control of clam harvests.

Sea urchin

Divers harvest sea urchins from shallow rocky bottoms off Nova Scotia. Urchins are marketed for their gonads in Japan. This fishery began in Nova Scotia in 1989 and increased substantially by 1995. Disease caused by a parasitic amoeba is a major threat to the sea urchin stock off Nova Scotia, and thus to the urchin fishery. By 1999, areas of SHACI Units 4, 5 and 6 within Halifax and Lunenburg Counties had lost all of their fishable urchin stock to disease, as did a major part of Guysborough County (DFO 2000a).

There are no designated urchin fishing seasons. Licenses are issued either as exploratory licenses or as full-time limited access licenses. There is no minimum landing for permanent license holders but temporary license holders must bring in 4 t/year. Harvested urchins must have at least a 50 mm test diameter. During the 1999–2000 fishing season there were 6 active and 3 inactive licenses in eastern Halifax County and 2 inactive licenses in western Halifax County. In Guysborough County there were 10 active and 5 inactive licenses and in Lunenburg County there were 2 inactive licenses (DFO 2000a).

Landings in 4Wk were substantially higher than in 4Xm, averaging at 212 t between 1995 and 2001, and peaking at 450 t in 1996. Urchin landings in 4Xm reached 155 t in 1995. In both areas, urchins are primarily harvested beginning in September, through the winter, and until April (ZIF 2005).

Snow crab

The snow crab fishery in SHACI Units 4, 5 and 6 falls within different management areas. The majority of snow crab fishing in this area occurs in eastern Nova Scotia and is managed by DFO as various Crab Fishing Areas (CFAs). SHACI Units 5 and 6 essentially lie within CFA subunit 24E and part of 24C (Figure 17-4). Reported snow crab landings for SHACI Units 5 and 6 are also discussed in terms of NAFO subdivision 4Wk. There is also a smaller snow crab fishery in SHACI Unit 4. DFO simply manages this area as NAFO division 4X. Landings for this area west of Halifax are also discussed in terms of NAFO subdivision 4Xm.

Eastern Nova Scotia

The snow crab harvest in eastern Nova Scotia began in the late 1970s. In 1979, landings peaked at 1634 t and then, by 1985, collapsed to what was believed to be near commercial extinction. Fortunately, a pulse of pre-recruits entered the fishery in 1986, and by 1993 the fishery reached a new peak of 2016 t (Tremblay et al. 1994). Landings of snow crab remained stable at approximately 1500 t per year from 1994 to 1997 and subsequently increased in the early 2000s (Biron et al. 2004). In 2003, landings were 10 608 t (Biron et al. 2004). According to logbook positions presented by Biron et al. (2002a), snow crab fishing in CFA subunit 24 occurred along the 12 nm limit and scattered areas further inshore roughly between Ship Harbour and Necum Teuch.

The snow crab fishery in eastern Nova Scotia is heavily managed. As of 1999, management included Individual Boat Quotas (IBQs), 100% dockside monitoring, mandatory logbook for both dockside monitoring and the DFO scientific database, landings no more than 10% soft shell crabs, at sea monitoring by certified observers, and a biodegradable panel on traps to prevent "ghost fishing". In 1998, sub-areas were introduced to ensure the distribution of fishing effort within eastern Nova Scotia (Biron et al. 2002a).

In CFA 24, the Total Allowable Catch (TAC) in 2001 was 4062 t and the IBQ was set at 72 009 kg. Temporary fishermen allocations were 2406 t. In 2001, there were 23 permanent snow crab fishing licenses and 59 temporary permit holders in CFA 24. Sub-areas 24E and 24C are mainly fished by temporary permit holders. In 2001, landings were made between June 1 and December, however, over 50% of landings were caught in June and July, and 90% were caught by September 15 (Biron et al. 2002a).

Management issues

There may be resource use conflict between the snow crab and the shrimp fishery in this area. Prior to 1998, the shrimp fishery was concentrated further offshore and did not interfere with nearshore crab fishing activities. Since 1998, however, the shrimp fishery has been shifting its effort toward the nearshore. A gentlemen's agreement was met between shrimp and crab fishermen in the area such that some fishing grounds in eastern Nova Scotia are reserved for the shrimp fishery for a given period of time. As well, there is reduced effort in the shrimp fishery during the snow crab fishery (Biron et al. 2002a).

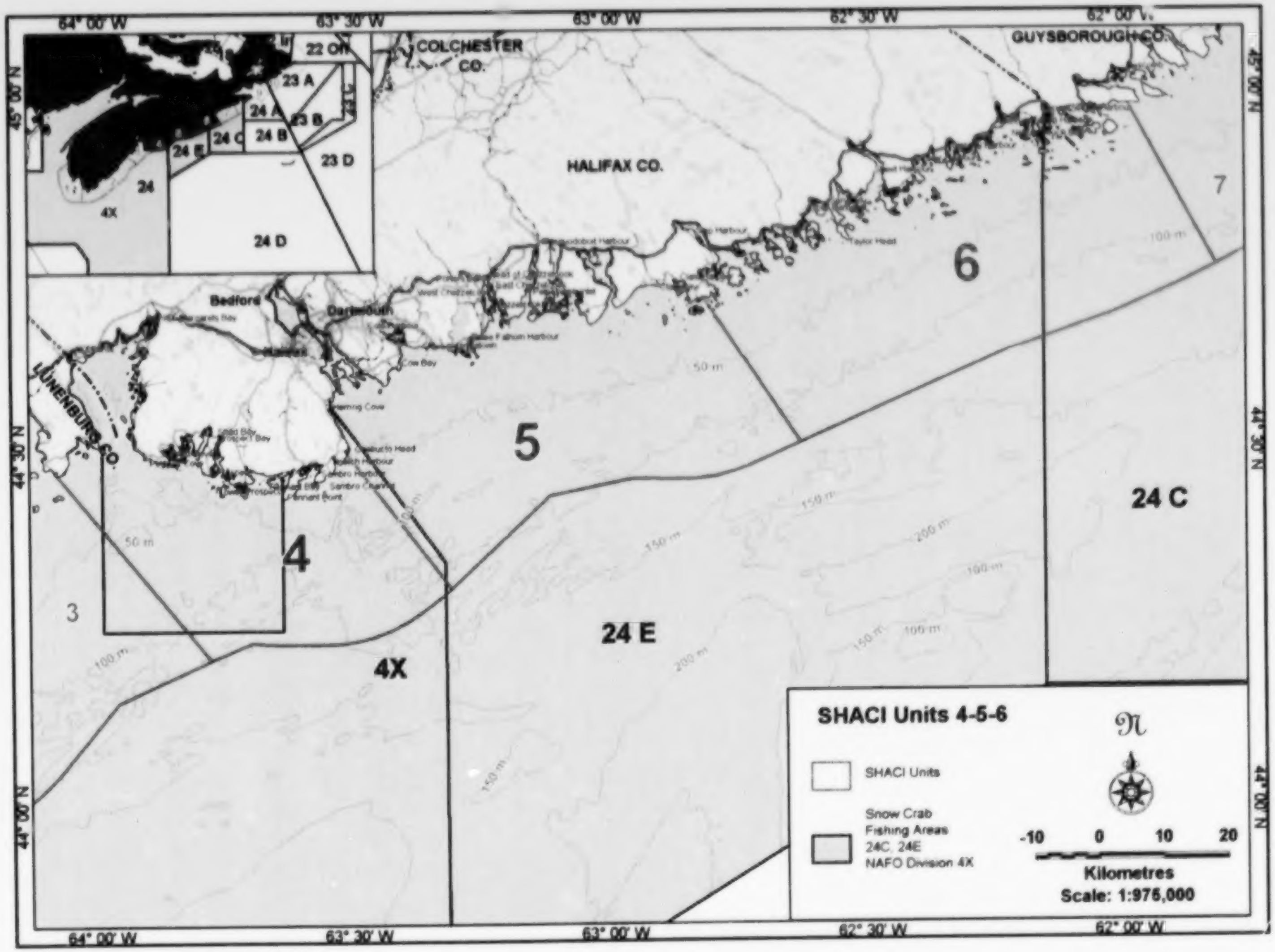

Figure 17-4: Snow crab fishing areas (CFAs) 24E, 24C (DFO) and NAFO division 4X. Basemap layers (NSGC).

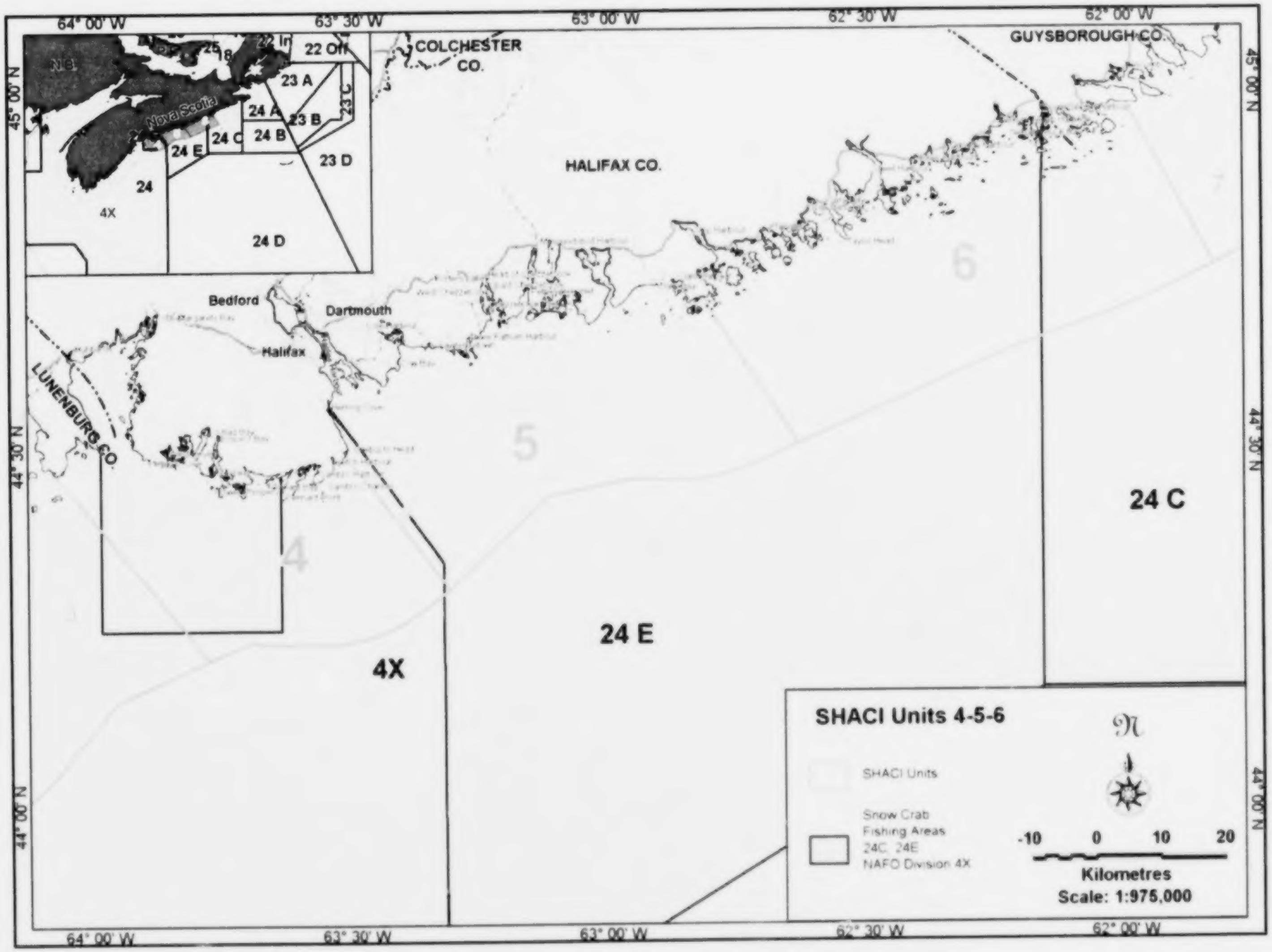

Figure 17-4: Snow crab fishing areas (CFAs) 24E, 24C (DFO) and NAFO division 4X. Basemap layers (NSGC).

According to Biron et al. (2002a), the length of the snow crab fishery in eastern Nova Scotia (from June 1st until early December) is unreasonable from a biological point of view. The problem lies in that fishing too late in the season increases the likelihood of catching recently moulted male crab. Capture of these immature males threatens future recruitment to the fishery. Biron and others (2002a) recommend that the snow crab fishery end before August 31.

4X

Snow crab found west of Halifax lie within NAFO division 4X and represent the southern limit of this species. In 4X, snow crab fishing is limited to two small areas of colder summer bottom temperature: the Roseway Basin, and the LaHave Basin area (Biron et al 2002b).

Snow crab harvesting in this area began in 1994 with the issuing of four exploratory snow crab permits. In 2000, these permits were converted to permanent licenses and a fishing season from November 1 to June 1 was established. Two temporary permits were also issued to native bands in the fall of 1999 and the winter of 2000, however, no fishing activities in this area have been reported by the bands. Two types of trap gear are commonly used in 4X: the Japanese style 4 foot diameter conical trap (175 trap limit), and the low cone 6 foot diameter type (30 trap limit). In 4X, landings have increased from 18 t in 1995 to 287 t in 2001 (Biron et al 2002b).

Information is lacking about the snow crab resource in this area. The available biomass is unknown and there is no scientifically justifiable data to determine the TAC. Biron et al. (2002b) conclude that the snow crab fishery in 4X should be considered a sporadic fishery.

4Wk and 4Xm

Landings for NAFO subunits are also considered. The snow crab fishery in 4Wk and 4Xm began in 1998 and has increased in recent years. Peak landings occurred in 2002 at 459 t in 4Wk, and in 2001 at 302 t in 4Xm (Tables 17-3 and 17-4). Based on average landings between 1995 and 2002, snow crab is the second most important invertebrate fishery in 4Xm, and the third most important invertebrate fishery in 4Wk.Yearly landings are slightly higher in 4Wk than in 4Xm. Snow crab landings in SHACI Units 4-6 are given in Table 17-6. Snow crab landings in SHACI Units 4-6 accounted for 74% of total snow crab landings from 4Wk and 4Xm from 1995-2002. Figure 17-5 shows snow crab landings in SHACI Units 4-6 in relation to landings in 4W and 4X.

Table 17-6: Snow crab landings in SHACI Units 4-6 (based on data from ZIF 2005)

1995	1996	1997	1998	1999	2000	2001	2002
-	0.2	-	25	64	226	595	625

*- denotes data not available

Snow crab is harvested using pots or traps. The snow crab fishery in 4Wk begins as early as June and continues as late as September but most commonly occurs in the later summer/early fall. In 4Xm, snow crab fishing begins as early as October and continues through the winter until as late as July. For the most part, however, the fishery in 4Xm occurs between November and May (ZIF 2005).

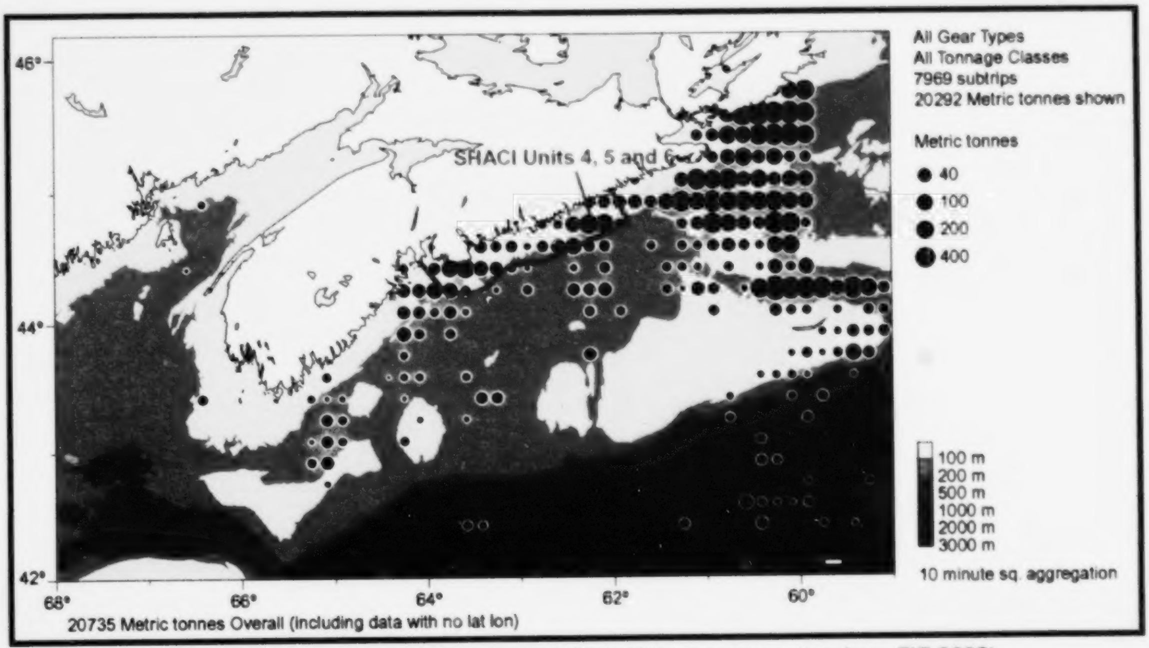

Figure 17-5: Snow crab landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Rock crab

Rock crabs are caught in NAFO units 4Wk and 4Xm. Of all invertebrate landings, rock crab is the 5th highest in 4Wk, and the 6th highest in 4Xm (Tables 17-3 and 17-4). Landings are, however, higher east of Halifax in 4Wk. Between 1995 and 2002, average rock crab landings were 19 t in 4Wk and 4 t in 4Xm. In 4Wk, rock crab landings peaked at 44 t in 1998 and have since decreased. In 4Xm, rock crab landings reached a maximum of 7 t in 2001 (ZIF 2005). From 1997 to 2002, rock crab landings in SHACI Units 4-6 (Table 17-7) were higher than in 4Xm. Figure 17-6 shows rock crab landings in SHACI Units 4-6 in relation to those in 4W and 4X.

Table 17-7: Rock crab landings in SHACI Units 4-6 from 1995 to 2002 (based on data from ZIF 2005)

1995	1996	1997	1998	1999	2000	2001	2002
-	-	14	33	13	11	20	11

*- denotes data not available

Rock crab is fished using pots or traps. The timing of the rock crab fishery varies somewhat from year to year. In recent years, the 4Wk rock crab fishery has generally occurred in April and May, and then again from July and into the winter months of December and January. The majority of landings are made in the late summer and fall between August and November. In 4Xm, rock crab is fished in April and May, and then usually again from November until January (ZIF 2005).

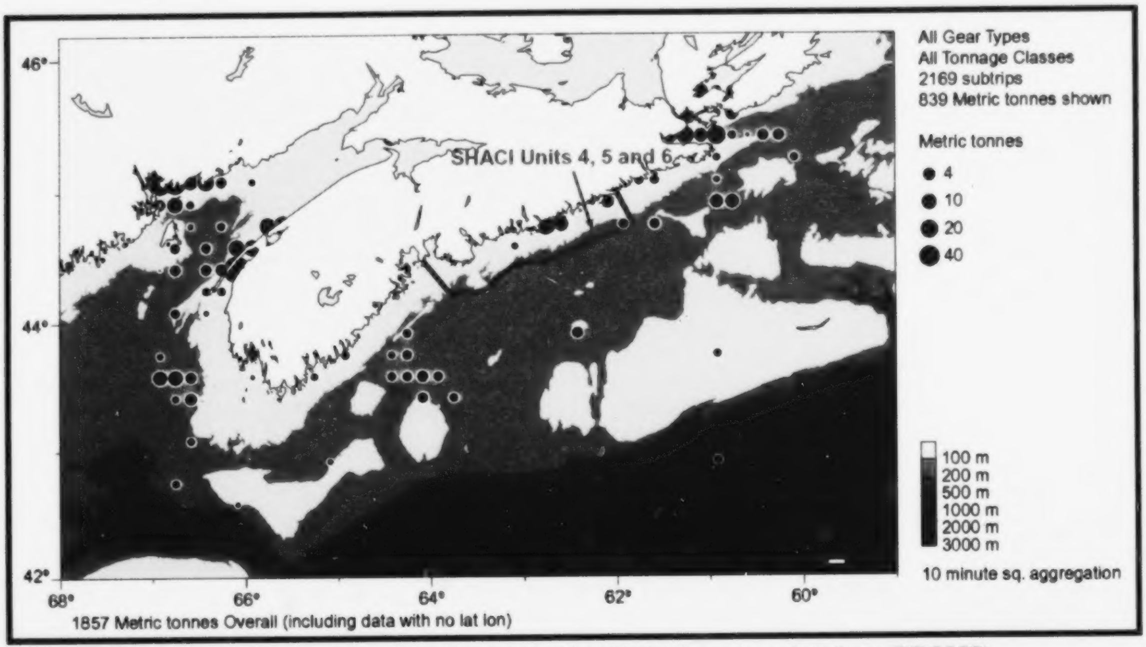

Figure 17-6: Rock crab landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Jonah crab

Jonah crab has been caught at low levels as a trap bycatch to the lobster fishery since the mid 1960s. A brief experimental fishery occurred in 1983 and 1984. The fishery was later reopened in 1997 in LFA 33 (Figure 17-2). The Jonah crab fishery is limited to an area 12–20 nm offshore. Jonah crab landings from NAFO units 4Wk and 4Xm are thus all made in areas outside the 12 nm inshore focus area of SHACI. For this reason, the Jonah crab fishery will not be described in detail.

Jonah crab landings are the third highest of all invertebrate landings in NAFO unit 4Xm (Table 17-4). Between 1995 and 2002, landings in 4Xm averaged 89 t/yr and peaked at 141 t in 2000. Landings east of Halifax in 4Wk are somewhat less substantial, averaging 8 t/yr, and peaking at 42 t in 2002 (Table 17-3) (ZIF 2005).

Jonah crab are fished using pots or traps. The timing of fishing activity has varied in recent years. In 4Wk, Jonah crab is fished between June and November but has also occurred in April and May. In 4Xm, Jonah crab is fished between March and November (ZIF 2005).

Shrimp

There is a small shrimp fishery in NAFO unit 4Xm. Average landings between 1995 and 2002 in this fishery were 10 t/year, making shrimp the fifth most important invertebrate fishery in 4Xm (Table 17-4). Shrimp landings in this area peaked in 1998 at 26 t. In 4Wk, shrimp were landed in very small numbers between 1995 and 2000 (Table 17-3) (ZIF 2005).

Shrimp is fished using pots or traps. The timing of shrimp fishing has varied from year to year. In 4Xm, shrimp fishing generally occurs sometime between November and April (ZIF 2005).

Fish

Groundfish

Many species of groundfish are fished commercially in SHACI Units 4, 5 and 6. Marine Fish Division Virtual Data Centre landings data indicate that, on average, the largest catches in unit 4Wk between 1995 and 2002 were for silver hake, pollock, redfish, white hake and cod (Table 17-8). Silver hake is by far the major fishery in this region, making up between 46% and 86% of the total annual groundfish catch since 1996. Groundfish landings in 4Wk were lowest in 1995, peaked in 1998, and have since been decreasing.

Southwest of Halifax in Unit 4Xm, the largest landings on average from 1995 to 2002 were for silver hake, redfish, cod, pollock and haddock (Table 17-9). Silver hake dominated the 4Xm fishery in 1999 and 2000 but in most years, the landings in 4Xm are more evenly spread between the different fisheries. Groundfish catches in 4Xm were relatively steady between 1995 and 1998, peaked in 1999, and have since decreased.

In recent years in SHACI Units 4-6, cod has dominated the groundfish landings (Table 17-10).

Table 17-10: Groundfish landings (t)* in SHACI Units 4-6 from 1995-2002 (based on data from ZIF 2005)

Species	1995	1996	1997	1998	1999	2000	2001	2002
Cod	37	96	88	81	56	51	57	65
Haddock	14	25	20	31	27	44	35	45
Pollock	33	39	18	89	17	14	4	4
Silver hake	-	-	2	32	22	13	1	0
Redfish	5	7	5	5	9	17	6	7
White hake	3	7	3	2	3	14	16	3
Total	92	174	136	240	134	153	119	124

* landings are to nearest tonne

Table 17-8: Groundfish landings (t)* in NAFO unit 4Wk (1995-2002) (based on data from ZIF 2005)

Species	1995	1996	1997	1998	1999	2000	2001	2002
Silver hake *(Merluccius bilinearis)*	2	1868	1593	3746	1819	1993	1647	1761
Pollock (*Pollachius virens*)	131	747	606	148	1067	145	128	32
Redfish (*Sebastes* sp.)	141	1081	755	240	119	33	35	7
White hake (*Urophycis tenuis*)	76	162	85	53	78	100	85	50
Cod (*Gadus morhua*)	29	55	65	79	64	51	37	41
Dogfish	6	0	8	0	27	16	72	161
Halibut (*Hippoglossus hippoglossus*)	15	37	19	26	36	32	33	52
Haddock (*Melanogrammus aeglefinus*)	8	34	22	32	27	30	42	41
Cusk (*Brosme brosme*)	16	28	29	34	32	22	17	23
Red hake (*Urophycis chuss*)	0	0	0	0	20	15	12	11
Greysole (*Glyptocephalus cynoglossus*)	5	18	7	2	2	6	4	2
Monkfish (*Lophius americanus*)	2	6	5	6	6	5	3	3
Unspecified flounder	0	10	4	1	1	4	0	1
Unspecified groundfish	0	3	1	0	4	1	0	0
Catfish	2	3	4	4	3	5	3	2
Yellowtail flounder (*Limanda ferruginea*)	2	1	1	0	4	0	0	0
Plaice (*Hippoglossoides platessoides*)	0	0	1	0	0	2	0	0
Totals	435	4053	3205	4371	3309	2460	2118	2187

* landings are reported to nearest tonne

Table 17-9: Groundfish landings (t)* in NAFO unit 4Xm (1995-2002) (based on data from ZIF 2005)

Species	1995	1996	1997	1998	1999	2000	2001	2002
Silver hake	25	4	85	327	3359	1587	258	110
Redfish	1298	816	884	294	581	429	145	121
Cod	304	473	462	478	399	291	252	231
Pollock	220	312	306	258	249	153	146	77
Haddock	95	89	91	142	180	224	228	209
White hake	72	91	95	49	88	106	117	72
Dogfish	22	15	32	34	76	133	86	272
Cusk	74	60	60	57	61	55	71	48
Greysole	50	45	61	46	17	17	6	1
Monkfish	10	14	29	28	24	33	15	14
Catfish	16	17	20	25	15	8	11	10
Halibut	10	16	14	11	9	16	21	17
Red hake	0	0	1	0	17	23	3	2
Unspecified flounder	8	9	8	2	5	3	1	1
Yellowtail	4	4	4	7	4	2	1	1
Plaice	0	1	5	13	2	1	1	1
Winter flounder	12	1	0	0	0	0	0	1
Unspecified groundfish	2	1	2	1	2	1	0	0
Totals	2222	1968	2159	1772	5088	3082	1362	1188

* landings are to nearest tonne

Cod

Cod fishing in this area began in the 1700s and remained primarily an inshore fishery until the 1960s (DFO 2000b). The cod fishery in SHACI Units 4, 5 and 6 are considered part of the NAFO 4VsW (eastern Scotian Shelf) and 4X/5Y (southern Scotian Shelf) cod stocks (Figure 17-1).

4Wk

Cod fishing in unit 4Wk, which includes areas east of Chebucto Head, has been closed since 1993. In this area, cod may only be caught as bycatch in other directed fisheries and in the Sentinel Program Commercial Index catch (DFO 1998b). Since 1995, cod has been caught in this area, using bottom trawls, longlines, gillnets, handlines and Danish seines. Cod is landed year round, but the majority is caught by longliners in July, August and September (ZIF 2005). Despite the closure of this fishery, it has not recovered and its short-term prospects are dismal. Productivity is low, mortality is high, and the spawning stock biomass, while stable, has not rebuilt since the fishery closed in 1993. DFO (1998b) cautions that even bycatch in other fisheries may threaten the recovery of the 4VsW cod stock. Successful recruitment and subsequent survivorship are required for this cod stock to rebuild strongly (DFO 1998b).

4Xm
A directed cod fishery remains in unit 4X on the southern Scotian Shelf. Quotas are set low, however, which causes many quota groups to treat cod as bycatch as they pursue other fish species such as haddock. Unit 4X is open to cod fishing year round, although winter-spring landings have declined since 1992 (Clark et al. 2000). Landings peak in June and July. Minimum mesh size and hook size regulations are present in unit 4X to reduce the catch of juvenile cod, and nearby Browns Bank is closed yearly from February 1-June 15 (DFO 2000b). The hook and line fishery accounted for roughly half of the landings from unit 4X between 1980 and 2000, with approximately 10% coming from the gill net fishery and the remainder from the dragger fleet (Clark et al. 2000). Cod catches in unit 4Xm are given in Table 17-11. Landings from SHACI Units 4-6 are shown in Table 17-10, and represent roughly 18% of landings from the directed fishery in 4Xm from 1995 to 2002. Figure 17-7 shows cod landings in SHACI Units 4-6 in relation to those in 4W and 4X.

McKenzie (1940) described the fall spawning of cod for Halifax Harbour and around Sambro Head to St. Margarets Bay. A seasonal gill net fishery which targeted fish aggregating in the deeper water of Sambro Head in the fall landed roughly 1000 t of cod annually (Clark et al. 2000). For a period in the 1980s fish in this area were also targeted by large draggers in the winter fishery. The fishery began to decline in the early 1980s, however, and has now all but disappeared. In recent years, fish in spawning state have been caught in this area and juvenile cod were captured with a beach seine in Halifax Harbour in spring of 1999 and 2000 (Clark et al. 2000).

The future of cod fishing in 4X depends largely on the incoming recruitment of juvenile fish to the spawning population (Clark et al. 2000). The 1998 and 1999 year classes of cod in this region are considered strong, however, measures must still be taken to ensure that these younger fish are not targeted by the fishery before they reach maturity (DFO 2000b).

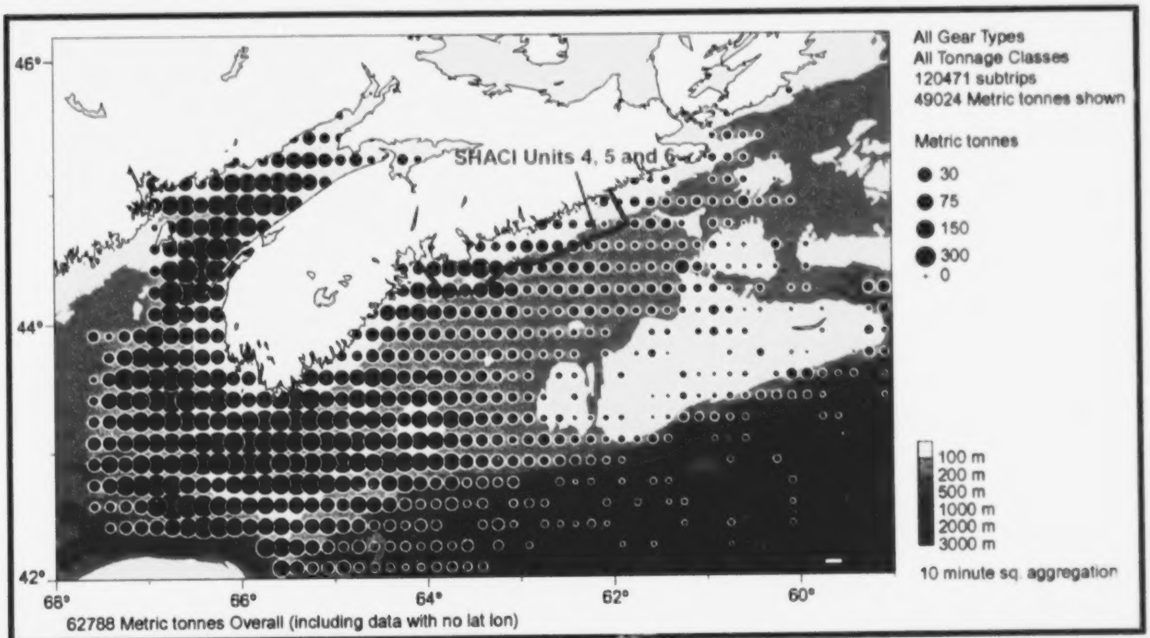

Figure 17-7: Cod landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Table 17-11: Nominal catch of cod in unit 4Xm (adapted from Clark et al. 2000)

Year	Catch	Year	Catch
1968	3251	1985	3006
1969	2413	1986	2914
1970	2851	1987	2676
1971	2750	1988	1502
1972	3124	1989	1370
1973	2130	1990	1846
1974	2243	1991	2552
1975	81	1992	1523
1976	1973	1993	1364
1977	184	1994	828
1978	2812	1995	293
1979	6565	1996	466
1980	5205	1997	453
1981	4767	1998	477
1982	5255	1999	397
1983	3437	2000	208
1984	2255		

Pollock

Previous assessments of pollock considered that the management unit was comprised of 4VWX5YB and 5Zc (Neilson et al. 2004) in which there were likely multiple pollock stocks (Annand et al. 1989). However, information on population complexity suggested that a single management unit was not appropriate (Neilson et al. 2003). Thus, stock assessments now consider eastern and western stock components (DFO 2004a, Neilson et al. 2004). SHACI Units 4-6 are located within the eastern stock component (4VW and 4Xmn) (Figure 17-1). Pollock landings from SHACI Units 4-6 are given in Table 17-10, and do not constitute a significant proportion of total landings in units 4W and 4X (Figure 17-8).

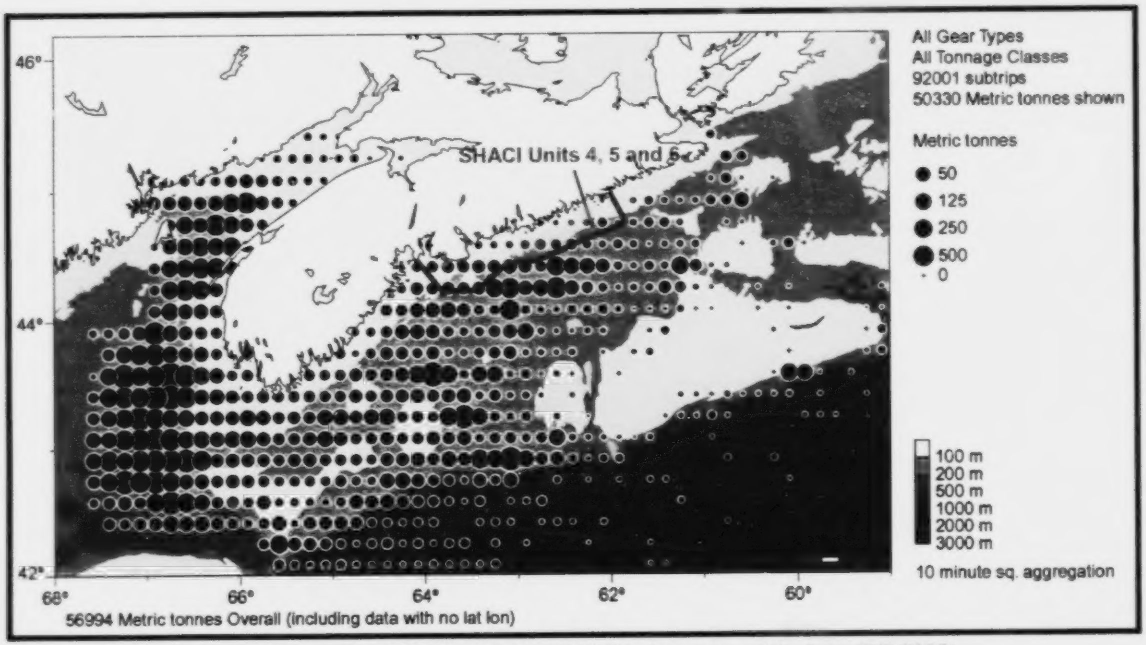

Figure 17-8: Pollock landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Canadian landings of pollock peaked in 1987 at 45 000 t but since then have decreased sharply (Neilson et al. 2004). In recent years, the contribution to total landings made by the eastern component has followed a declining trend (Table 17-12). This is due, in part, to management measures that have had considerable impact on the fishery. For example, the cod management unit in 4VsW has been closed since September 1993, thus restricting opportunities for pollock fishing on the eastern Scotian Shelf (Neilson et al. 2004). Summer research survey vessels indicate that total mortality of the eastern component is high and increasing, despite low landings from the fishery (DFO 2004a). DFO (2004a) advises that large scale directed pollock fisheries in the slow-growing eastern component should not be considered until the component recovers.

Pollock are fished both in directed fisheries, and as bycatch in the cod and haddock fisheries and the small-mesh silver hake and redfish fisheries (DFO 2001a). Pollock are primarily caught with otter trawl, gillnet and longline. Fishing occurs year round but Canadian fishery landings generally peak in June and July, although occasionally high landings are observed in the winter (Neilson et al. 2004).

Table 17-12: Landings ('000s t) in pollock fisheries (DFO 2004a)

Year	1970-1979 average	1980-1989 average	1990-1999 average	2000	2001	2002	2003
Eastern component	7.8	21.2	7.8	0.7	0.8	0.4	0.2
Western component	13.9	16.5	11.6	4.8	5.4	7.0	8.1
Total	21.7	37.7	19.4	5.5	6.2	7.4	8.3

In the western component, research vessel biomass indices declined from the early 1980s to a low in 2000 and have subsequently increased, although remain lower than in the 1980s (DFO 2004a). The 1998 and 1999 year classes were relatively strong in recent years. There are, however, early indications of weak 2000 and 2001 year classes. The population biomass is lower than that associated with improved recruitment. Fishing mortality estimates increased from the early 1980s until 1994, despite decreased landings. Mortality declined in 1995 and 1996, increasing to a maximum when landings increased in 1998. In recent years, reduced quotas and harvests have contributed to a decline in fishing mortality for ages 4-9 but mortality remains high, especially for older fish (ages 6-9).

Silver hake

The silver hake fishery in SHACI Units 4, 5 and 6 is managed as part of NAFO division 4VWX (Figure 17-1). Before 1977, the area, mesh size and season of the silver hake fishery in these areas were unrestricted. Since 1994, restrictions to minimize bycatch of cod, haddock and pollock have been introduced. Fishing for silver hake is not permitted in depths less than 190 m and a separator grate must be used in the lengthening piece of the trawl (DFO 2001a).

Silver hake have, on average, made up the majority of groundfish catches in both 4Wk and 4Xm since 1995 (ZIF 2005). However, in SHACI Units 4-6, silver hake was the fourth major fishery during this period (Table 17-10). The fishery uses otter trawls and occurs year round. As mentioned, the silver hake fishery is not permitted in water shallower than 190 m, and therefore would not be considered a coastal fishery. As indicated in Figure 17-9, most silver hake landings are made outside the 12 nm inshore boundary which is the focus area of SHACI.

The status of the silver hake population off Nova Scotia is unclear. Based on DFO survey results, silver hake in 4VWX has a low biomass and a high total mortality. At the same time, however, overall trends of population status are inconclusive. As a result, a freeze on catches at 1997-1999 levels was recommended by DFO (2001a).

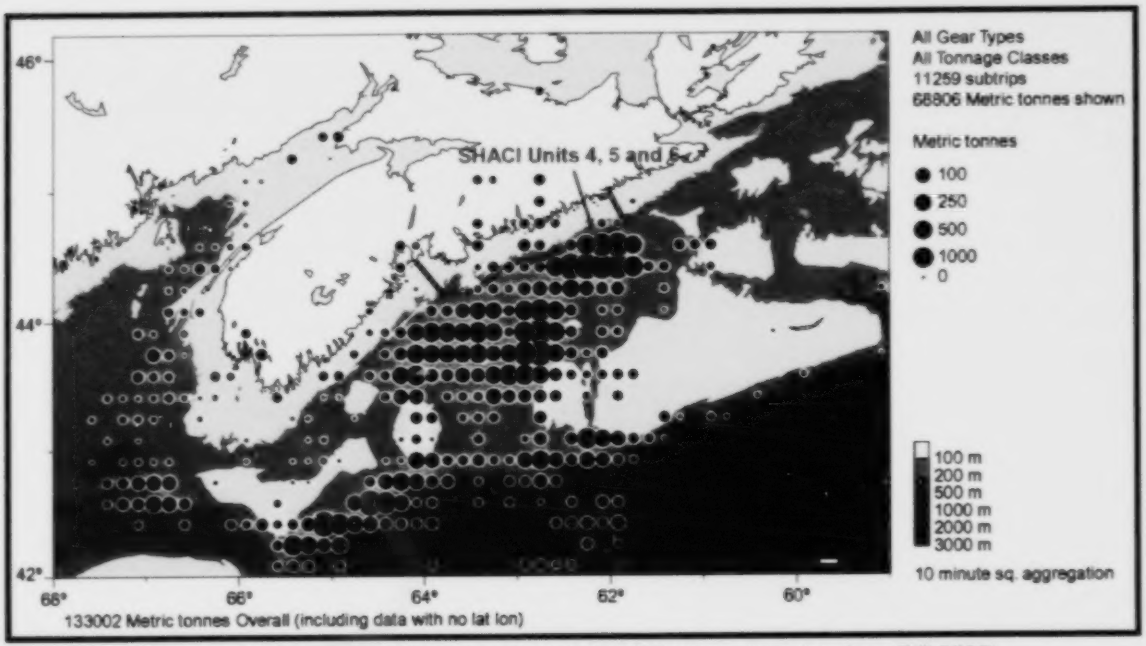

Figure 17-9: Silver hake landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

White hake

The white hake found off Halifax County are considered part of the 4VWX and 5Zc management area (Figure 17-1). When quota reductions were put in place on the Scotian Shelf for traditionally sought species like cod, haddock and pollock, fishing effort was directed to species, such as white hake, that were historically of no commercial value (Bundy et al. 2001). Fishing effort for white hake in 4VWX and 5Zc was unregulated in Canada until 1996. Since 1999, white hake has only been caught as bycatch in longline, gillnet and small otter trawl fisheries that target halibut, cusk and other groundfish. In recent years, landings in all areas have declined (DFO 2001b). Figure 17-10 shows white hake landings in SHAC I Units 4-6 in relation to units 4X and 4W.

4Xm

In 4X, white hake is caught year round but the majority of fishing takes place from late spring to early autumn (Bundy et al. 2001). The majority of landings in 4Xm come from gillnets and longlines but <65 foot otter trawls, handlines, and Danish Seines are also used (ZIF 2005). In 4X, white hake is caught as bycatch in the cod, haddock and cusk longline fisheries, in the pollock gillnet fishery, and in the haddock, redfish, pollock, cod and monkfish otter trawl fisheries (Bundy et al. 2001). A substantial proportion of the white hake landed in the 4VWX and 5Zc management area comes from 4X (DFO 2001b).

The status of white hake is considered poor in 4X but shows signs of recovery. In 4X, abundance was poor during most of the 1990s but is increasing and continuing to improve. Production, however, has declined since the 1980s. Although white hake in this area show signs of recovery, DFO (2001b) cautions that any increase in catch rates could jeopardize the rebuilding of this stock.

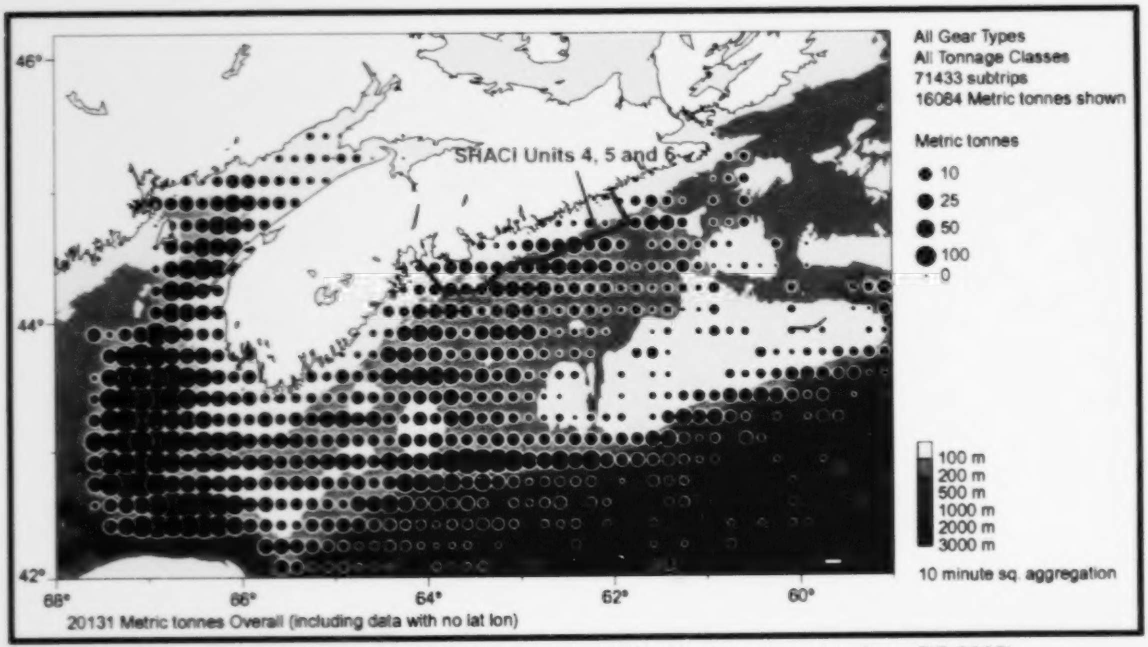

Figure 17-10: White hake landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

4Wk

The 4W white hake fishery occurs predominantly in the summer but some activity also occurs in the first 6 months of the year (Bundy et al. 2001). The majority of white hake landings in this area comes from longliners but gillnets, <65 foot otter trawls, handlines, pots and Danish Seines are also used (ZIF 2005). Halibut is the main longline fishery that catches white hake as bycatch (Bundy et al. 2001).

In 4W, abundance has remained very low and production has been poor since the early 1990s. The general status of white hake in 4W is considered poor and requires rebuilding (DFO 2001a).

Redfish

The redfish found in SHACI Units 4, 5 and 6 are part of the Unit 3 redfish management area (Figure 17-11). The redfish resource in Unit 3 is considered stable. Since 1995, in 4Wk and 4Xm redfish landings have been on average the third and second greatest contributors to total groundfish landings, respectively (ZIF 2005).

In Unit 3, redfish landings peaked at almost 7000 t in 1983 and then declined to 2000 t by 1991. After 1992, landings increased until 1996, and then declined once again. Landings increased after 1992 due to increased fishing effort by otter trawlers that were no longer fishing for more valuable species; this increase did not reflect an increase in redfish abundance. The decrease in landings since 1996 resulted from decreased effort by otter trawls and reflected decreased demand at processing plants for the smaller fish rather than a decrease in redfish abundance (DFO 2001a).

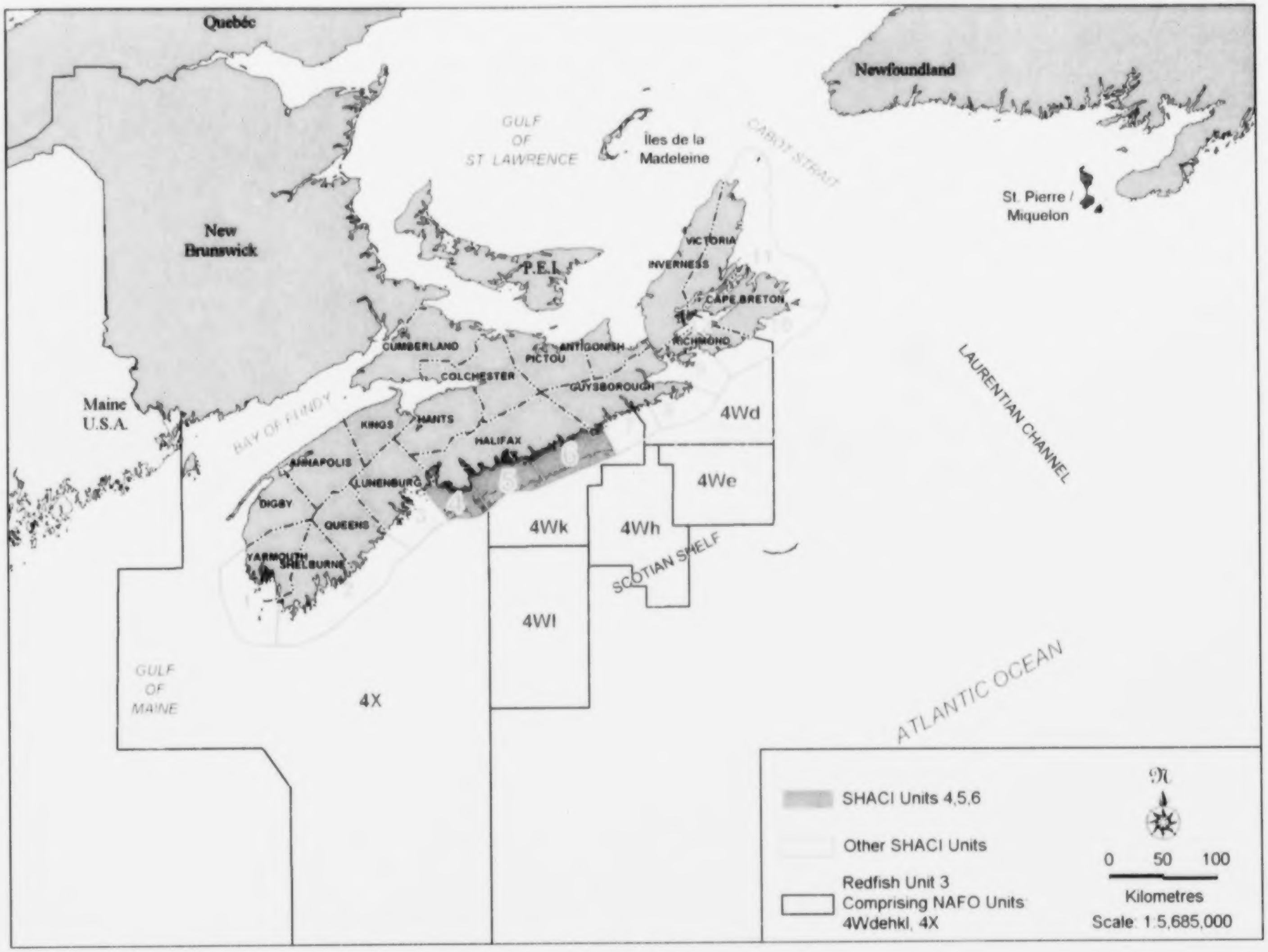

Figure 17-11: Redfish Mangement Unit 3 (DFO). Basemap layers (NRCan).

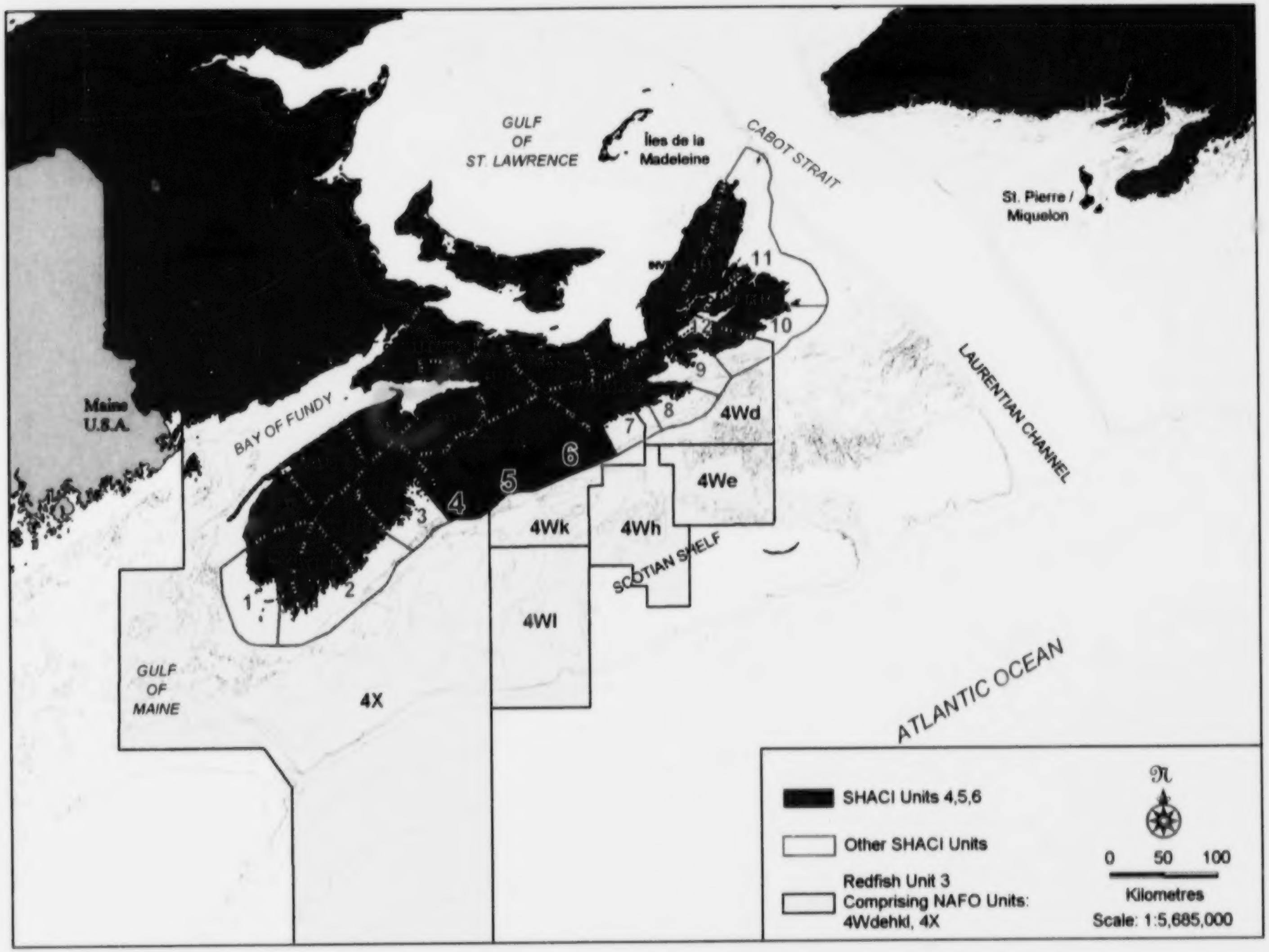

Figure 17-11: Redfish Mangement Unit 3 (DFO). Basemap layers (NRCan).

Since 2003, the otter trawls that are used to catch redfish in Unit 3 have 110 mm mesh (Hurley pers. comm. 2005). In 4X, regulations limit the bycatch of other groundfish species to 10% by weight of redfish caught. In 4W, bycatch is limited to 2% by weight of each cod and haddock. Pollock accounts for most of the reported bycatch in Unit 3 and has increased steadily since 1994 (DFO 2001a).

Landings are also considered in terms of NAFO subunits 4Wk and 4Xm. In 4Wk and 4Xm, the majority of redfish are caught by otter trawl but longlines, handlines, gillnets and Danish seines are also used. Fishing proceeds year round with the majority of catches occurring in the summer and fall months. Redfish landings in 4Xm are greater than in 4Wk (Tables 17-8 and 17-9) (ZIF 2005). Redfish landings in SHACI Units 4-6 are shown in Figure 17-12.

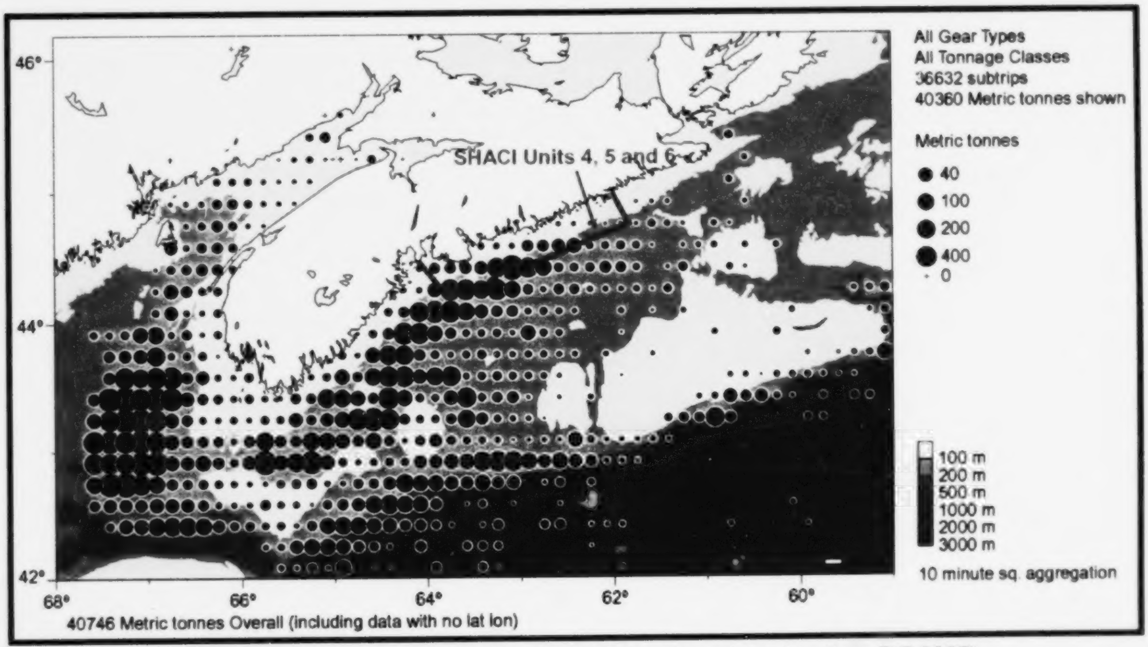

Figure 17-12: Redfish landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Haddock

Haddock in SHACI Units 4-6 are part of the NAFO Divisions 4X/5Y and 4TVW management units. Haddock landings in SHACI Units 4-6 are shown in Figure 17-13.

4X

Long-term reported annual (1948-2002) landings of haddock in NAFO Division 4X/5Y average approximately 18 000 t (Hurley et al. 2003). During the mid to late 1960s and early 1980s, landings exceeded 30 000 t. Landings subsequently declined and have been below the long-term average since 1984. In 1989, landings reached 6800 t when it was recommended that the fishery be maintained at the lowest possible level and the mobile gear fleet was closed in mid-season. From 1989 landings increased, exceeding 10 000 t in 1992 under a Management Plan that called for a bycatch fishery only. Landings reached the lowest level in recent history in 1994 (4406 t) under stringent fishing plans and a quota of 4500 t. Quotas have not been exceeded since then. A total allowable catch of 8100 t was established in 1999 and remained for the next three years. Although initially set at 8100 t for the 2003/2004 fishing year, the quota was increased to 10 000 t in September 2003 (Hurley et al. 2003).

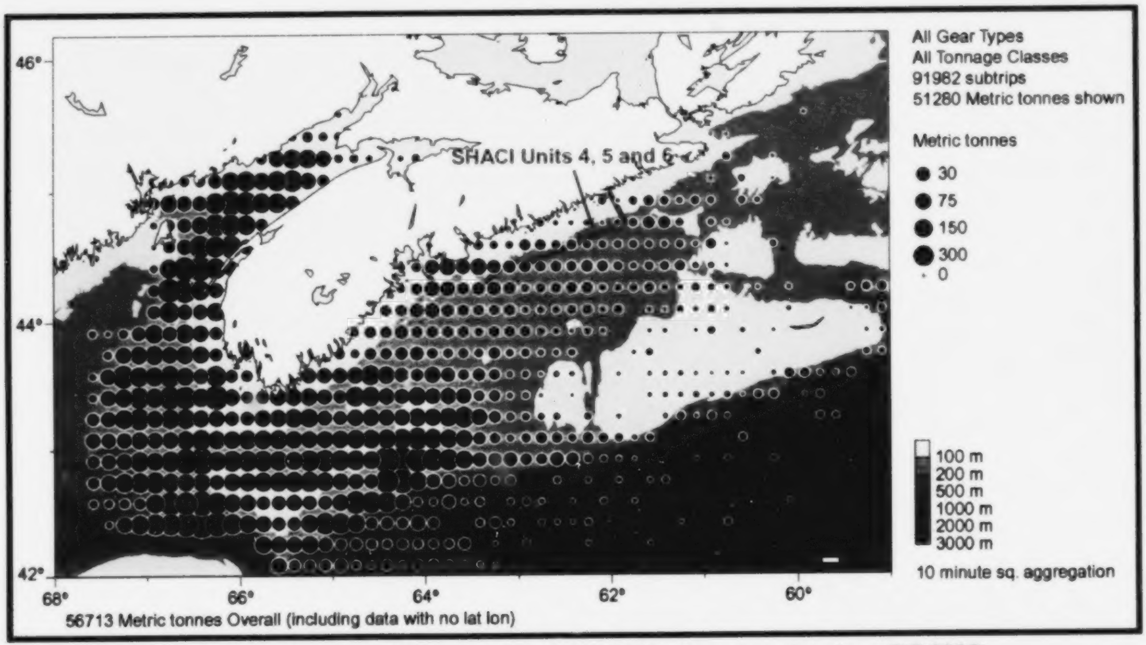

Figure 17-13: Haddock landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Between 1977 and 1989, the fishery was dominated by the mobile gear sector. The fixed gear sector took a larger proportion of the landings between 1990 and 1994 but the proportion taken by the mobile gear sector has increased since then and was 71% in 2002 (Hurley et al. 2003). Longlines account for the majority of fixed gear landings. Landings by handlines are small and have been declining since 1994.

4TVW

The eastern Scotian Shelf haddock is contained within NAFO Division 4TVW. Historically, this fishery has been very productive but in recent years this has not been the case. Total landings peaked in the mid 1960s, followed by a rapid decline to the mid 1970s (Frank et al. 2001). During this period foreign landings frequently exceeded domestic landings. A second peak in landings occurred in the mid 1980s, followed again by a decline in the early 1990s. The decadal annual landings were 25 000 t in 1960-1969, 5000 t in 1970-1979, and 11 500 t in 1980-1989 (Frank et al. 2001). The fishery for haddock collapsed in the 1990s and has been closed to directed fishing since 1993. Since 1994, bycatch in other fisheries has averaged 128 t. Otter trawls have generally dominated catches. In Division 4W during 1989-1993, however, fixed gear landings exceeded otter trawl landings due to an exemption for fixed gear in the closed area.

Spawning stock biomass has been increasing steadily since the closure of the fishery in 1993 and in 2000 exceeded the 1970-2000 average (Frank et al. 2001). Despite the period of steady recovery of biomass, the population is increasingly dominated by small young fish (Mohn and Simon 2002). The 1999 year class is the largest seen in the 32 year summer RV series. However, this stock is severely depressed and shows no signs of recovery (Mohn and Simon 2002).

Pelagic fish

Several pelagic fish species are fished in SHACI Units 4, 5 and 6. The ZIF (2005) groups diadromous fish with marine pelagic species, therefore both pelagic and diadromous fish landings are presented in Tables 17-13 and 17-14.

East of Halifax in 4Wk, herring makes up the vast majority of pelagic fish landings, followed by mackerel, swordfish, porbeagle shark and alewife (Table 17-13). Total landings in this area between 1995 and 2002 averaged 6568 t and peaked in 1996 at 11 110 t.

Table 17-13: Pelagic fish landings (t)* in NAFO Unit 4Wk (1995–2002) (based on data from ZIF 2005)

Species	1995	1996	1997	1998	1999	2000	2001	2002
Herring	27	10 846	10 260	4450	8209	3729	4002	8999
Mackerel	170	139	174	7	27	4	4	8
Swordfish	138	23	14	10	4	37	40	118
Porbeagle shark	30	37	68	33	43	74	15	61
Alewife	64	47	35	22	23	18	2	4
Bluefin tuna	1	7	14	21	43	26	33	24
Dogfish	6	0	7	0	0	16	67	161
Eel	6	7	8	8	4	9	9	-
Blue shark	0	1	1	0	11	1	9	0
Smelt	0	0	0	3	7	3	0	-
Mackerel shark	3	1	1	1	1	1	1	1
Skate	1	2	1	2	0	0	0	0
Unspecified shark	1	0	0	0	0	0	0	1
Totals	447	11 110	10 583	4557	8372	3918	4182	9377

* landings are to nearest tonne

Average total pelagic fish landings between 1995 and 2002 in 4Xm (2929 t/year) are lower than in 4Wk (Table 17-14). Making up 80% of average total pelagic fish landings between 1995 and 2002, mackerel is the main pelagic species caught in 4Xm. Herring, bluefin tuna, alewife and dogfish also commonly landed in this area.

Table 17-14: Pelagic fish landings (t)* in NAFO Unit 4Xm (1995–2002) (based on data from ZIF 2005)

Species	1995	1996	1997	1998	1999	2000	2001	2002
Mackerel	4141	2394	3123	1886	3045	2444	981	680
Herring	334	782	599	89	200	197	419	78
Bluefin tuna	76	133	112	132	76	71	33	34
Dogfish	22	15	32	34	0	133	86	272
Alewife	137	79	56	55	51	102	1	1
Porbeagle shark	3	19	35	12	16	21	12	18
Eel	12	9	11	11	7	9	0	-
Swordfish	14	3	1	1	1	16	9	-
Skate	12	8	8	8	0	2	2	1
Mackerel shark	0	0	1	1	1	2	1	1
Blue shark	1	3	0	0	0	0	0	0
Smelt	0	0	0	2	0	0	0	-
Unspecified shark	0	0	0	1	1	1	0	1
Totals	4752	3445	3978	2232	3398	2998	1544	1086

* landings are to nearest tonne

In SHACI Units 4-6, herring accounted for the majority of pelagic fish landings between 1996 and 2002 (Table 17-15).

Table 17-15: Pelagic fish landings (t)* in SHACI Units 4-6 (based on data from ZIF 2005)

Species	1995	1996	1997	1998	1999	2000	2001	2002
Herring	-	998	1722	850	1296	1695	1871	3938
Mackerel	-	-	101	25	5	24	31	36
Bluefin tuna	5	48	56	38	56	36	31	17
Porbeagle shark	0	2	6	5	2	2	5	4
Swordfish	1	0	-	-	1	4	0	1
Blue shark	0	2	0	0	2	-	-	-

* landings are to nearest tonne

Herring

The 4VWX herring fisheries are divided into four components: Southwest Nova Scotia/Bay of Fundy spawning component, Offshore Scotian Shelf banks spawning component, Coastal Nova Scotia spawning component, and Southwest New Brunswick migrant juveniles (DFO 2004b). SHACI Units 4-6 are in the Coastal Nova Scotia spawning component which includes the South Shore, Eastern Shore and Cape Breton.

Herring in SHACI Units 4, 5 and 6 was traditionally fished in the spring as bait. Since 1996, fishermen in this area have participated in a herring roe fishery developed on several coastal spawning grounds along the Atlantic coast of Nova Scotia (Melvin et al. 2001). In coastal Nova Scotia, the herring fishery has no overall quota and the size and historical performance of many spawning groups is poorly documented and understood (DFO 2002a). Recent research efforts have improved our understanding in some areas, however, knowledge gaps remain. Little is known about stock structure, the historical fishery is not well documented and there is limited survey information. These factors confound efforts to estimate current fishing mortality (DFO

2002a). Due to their relatively small size and proximity to shore, spawning groups within this component are vulnerable to fishing pressure (Stephenson et al. 2000).

Despite the pressure to increase and develop new coastal fisheries, in recent years DFO has recommended no effort increases to coastal herring spawning areas without adequate information on the state of the spawning group, and no new herring fisheries developed when uncertainty exists regarding stock composition and degree of mixing (DFO 2004b).

In recent years there has been an increase in the number of active gillnet licenses in the Coastal Nova Scotia spawning component. In the 2002-2003 quota year, gillnet and trap fisheries landed 9162 t of herring in this spawning component (Power et al. 2004). Biomass estimates from surveys of the major coastal Nova Scotia spawning components were higher in 2003 with large increases in estimated SSB for the Eastern Shore, Little Hope and Glace Bay (Table 17-16) (Melvin et al. 2004).

Within SHACI Units 5 and 6, an area east of Halifax and along the Eastern Shore has been part of the fall herring roe fishery since 1996. Set nets are the most used gear type in the herring fishery in this area (Clark et al. 1999). Fished in September and October, the roe gillnet fishery for the Eastern Shore area landed over 2700 t in 2003 (Table 17-16) (DFO 2004b, Power et al. 2004). The catch was composed of spawning fish mainly in the 5-7 year range. Off of Halifax, herring purse seine catches were lower in 2003 than in previous years (Table 17). Of all fishing grounds in 4VWX, purse seine catches from off of Halifax comprised an average of 1% for the 1991-2002 period (Power et al. 2004).

Table 17-16: Recorded landings, estimated spawning biomass and exploitation of herring from major gillnet fisheries in the Halifax/Eastern Shore Spawning Component (adapted from Power et al. 2004).

	1996	1997	1998	1999	2000	2001	2002	2003
Landings (t)	1280	1520	1100	1628	1350	1898	3334	2727
Survey SSB (t)	-	-	8300	20 200	10 900	16 700	41 500	77 400
Exploitation (landings/SSB, %)	-	-	13	8	12	11	8	4

Table 17-17: Herring purse seine catches (t) off Halifax (adapted from Power et al. 2004)

1996	1997	1998	1999	2000	2001	2002	2003
11 800	13 770	4284	8669	1645	3977	5078	722

Landings are also considered in terms of NAFO subunits. More herring is landed east of Halifax in 4Wk than west of Halifax in 4Xm (Figure 17-14). Herring makes up the majority of the pelagic fish catch in 4Wk (Table 17-13). Average herring landings between 1995 and 2002 in 4Wk were 6315 t/yr and the maximum was reached in 1996 at 10 846 t. Herring landings are second in importance to mackerel landings in terms of pelagic fish in 4Xm. Here, average landings between 1995 and 2002 were 337 t/yr, with peak landings of 782 t occurring in 1996 (ZIF 2005).

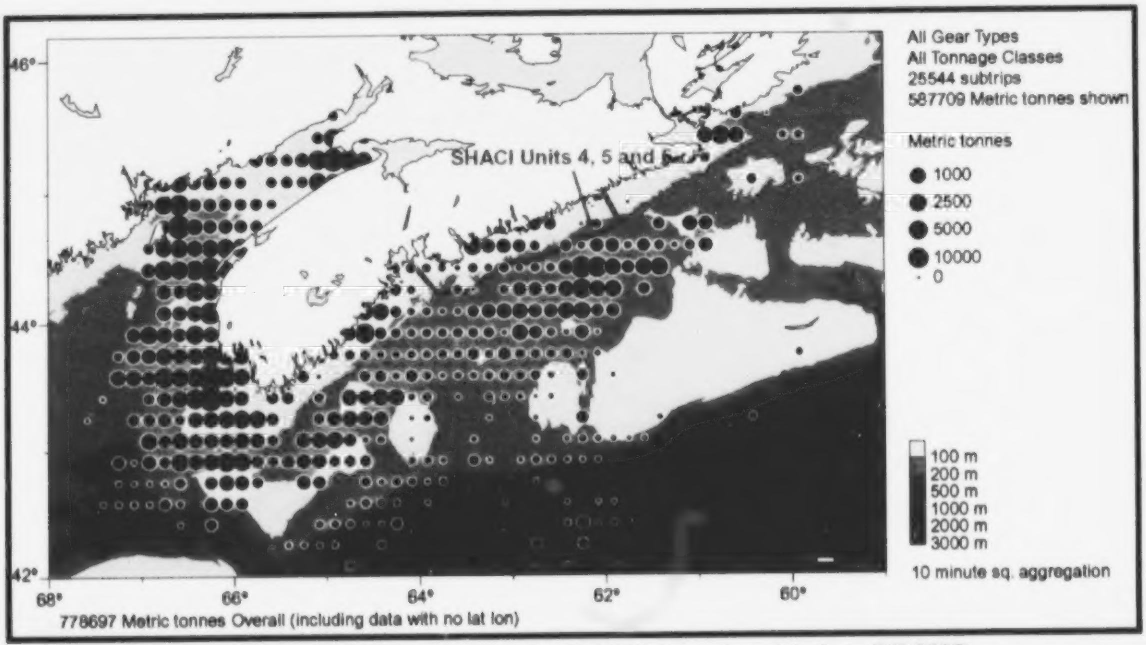

Figure 17-14: Herring landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Mackerel

As evidenced by landings data off Nova Scotia, the mackerel fishery is practiced close to the shore in 4Xm and 4Wk (Figure 17-15). The gear used to catch mackerel includes gillnets, traps, handlines and otter trawls (ZIF 2005). Mackerel is fished commercially, as bait and recreationally. In the summer, the recreational fishery is a popular tourist activity. Adult mackerel are generally fished from May to July (Bernier and Lévesque 1999).

The current population of mackerel in Canadian waters is considered low and similar to that measured in the early 1980s. In 2000, however, a high number of small mackerel were present in catches in the Maritimes (Grégoire et al. 2001). In 2003 catch at age was characterized by a very large number of fish from the 1999 year class (Grégoire et al. 2004).

From 1990 to 2002, the highest average annual landings in Canadian waters were recorded by Nova Scotia (6173 t) (Grégoire et al. 2004). Since 1995, mackerel landings in NAFO unit 4Wk have averaged at 66 t (Table 17-13). Landings dropped dramatically from 174 t to 7 t between 1997 and 1998, and have remained low since then. The fishery in 4Wk takes place between April and December, with the majority of the catch landed before the end of July (ZIF 2005).

In unit 4Xm, mackerel landings are much higher than in 4Wk, averaging 2337 t since 1995, and ranging from 4141 t in 1995 to 680 t in 2002 (Table 17-14). Fishing generally occurs between May and December (ZIF 2005). In SHACI Units 4-6, mackerel accounted for the second highest pelagic fish landings from 1995 to 2002 (Table 17-15).

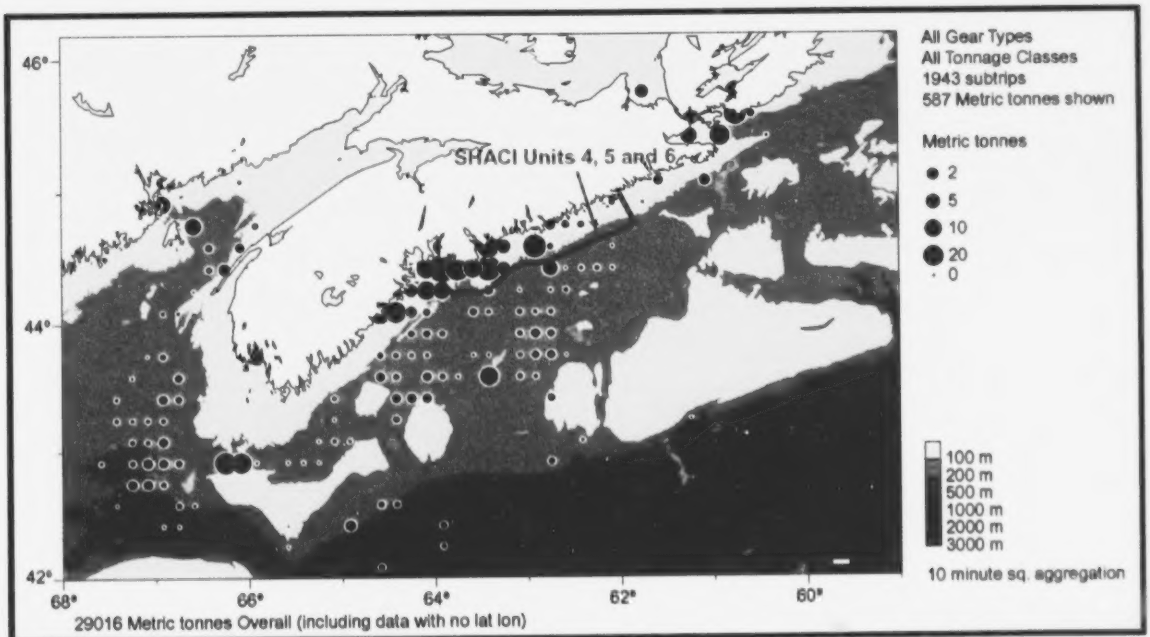

Figure 17-15: Mackerel landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Bluefin tuna

Bluefin tuna are fished in NAFO units 4Wk and 4Xm using traps, rod and reel, longlines and trawler lines. Since 1995, catches in 4Wk have averaged 21 t, and ranged from 1 t in 1995 to 43 t in 1999 (Table 17-13) (Figure 17-16). Tuna fishing in 4Wk generally occurs between August and November. Catches in NAFO unit 4Xm are substantially larger, ranging from 133 t in 1996 to 33 t in 2001, and averaging 83 t (Table 17-8) (ZIF 2005). Bluefin tuna landings accounted for the third highest pelagic fish landings in SHACI Units 4-6 from 1995-2002 (Table 17-15).

St. Margarets Bay is a tuna management area in which tuna trapnets are used at 24 licensed trapnet sites (DFO 2002b). Landings from St. Margarets Bay are given in Table 17-18.

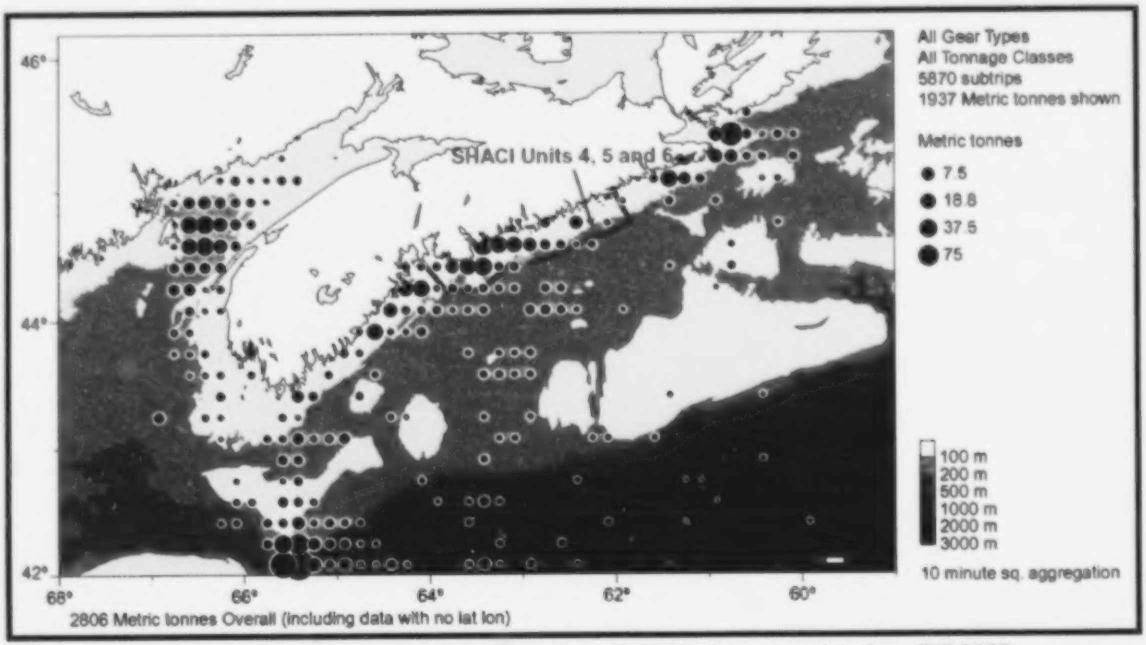

Figure 17-16: Bluefin tuna landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005). St. Margarets Bay trap catches are not shown.

Table 17-18: Bluefin tuna landings (t) from St. Margarets Bay (adapted from DFO 2002b and DFO 2004c)

Year	Landings (t)	Year	Landings (t)
1968	101	1986	1
1969	193	1987	17
1970	130	1988	18
1971	59	1989	-
1972	29	1990	2
1973	144	1991	-
1974	256	1992	2
1975	144	1993	28
1976	172	1994	80
1977	368	1995	72
1978	221	1996	91
1979	31	1997	59
1980	47	1998	68
1981	41	1999	44
1982	68	2000	16
1983	7	2001	16
1984	3	2002	28
1985	12		

Swordfish

The swordfish fishery off Nova Scotia was primarily a harpoon fishery until the early 1960s when swordfish fishermen began longlining. While there is no bycatch associated with swordfish harpooning, longlining can catch high numbers of sharks, other fish species, marine turtles, marine mammals and juvenile swordfish. During the 1960s, there were virtually no rules and regulations associated with the swordfish longlining fishery. There were no quotas, licenses, minimum size limits or fishing seasons (Fitzgerald 2000).

In 1972, the American Food and Drug Association placed a ban on swordfish imports into the United States due to health related concerns about mercury levels in swordfish flesh. During this ban, most swordfishing off Nova Scotia stopped until the ban was eventually lifted in 1978 (Fitzgerald 2000). Since 1996, Canadian regulations for swordfish longliners have included the release of all swordfish (dead or alive) smaller than 119 cm in length. Based on 10% observer coverage of the swordfish fishery in 1998, it is estimated that 51.7 t of swordfish (3887 swordfish) were released dead because they were undersized (Fitzgerald 2000).

In the 1960s, swordfish were captured in both inshore and offshore waters. The main inshore grounds were along the Eastern Shore of Nova Scotia, and particularly off the coast of Cape Breton Island (Tibbo et al.1961). In recent years, swordfishing has occurred in SHACI Units 4, 5 and 6, although the majority of fishing is concentrated outside the 12 nm boundary (Figure 17-17).

Average swordfish landings between 1995 and 2002 were higher in 4Wk (48 t) than in 4Xm (6 t) (Tables 17-13 and 17-14). Landings in 4Wk peaked in 1995 at 138 t, and in 4Xm in 2000 at 16 t (ZIF 2005).

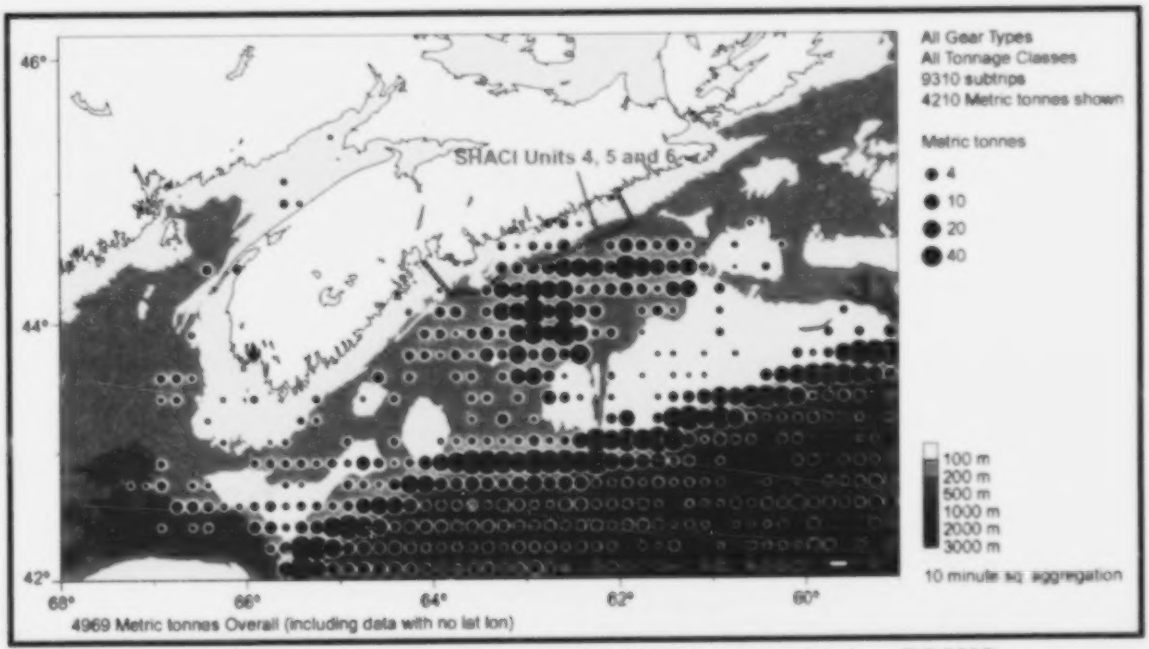

Figure 17-17: Swordfish landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Shark

There are two directed shark fisheries in Atlantic Canada: a recreational fishery for blue sharks (Figure 17-18) and a commercial fishery for porbeagle sharks (Figure 17-19). Sharks are also caught incidentally in other fisheries as bycatch. Canadian shark catch data report landings only, not bycatch (DFO 2002c).

The reported catch of blue sharks in the Canadian Atlantic grossly underestimates the actual catch mortality. New estimates of bycatch mortality suggest that the sum of landed catch and bycatch mortality has averaged 1000 mt annually since 1986 (Campana et al. 2004). The weight of sharks landed at recreational shark derbies has increased from approximately 4 mt in 1993 to roughly 20 mt in recent years. Blue sharks accounted for 99% of all sharks landed in Canadian Atlantic recreational shark derbies, all of which are currently located in Nova Scotia. An additional 13 mt is caught annually in the recreational catch and release fishery. Blue shark landings in Atlantic Canada peaked at roughly 250 mt in 1994, thereafter declining to 19 mt in 2003 (Campana et al. 2004).

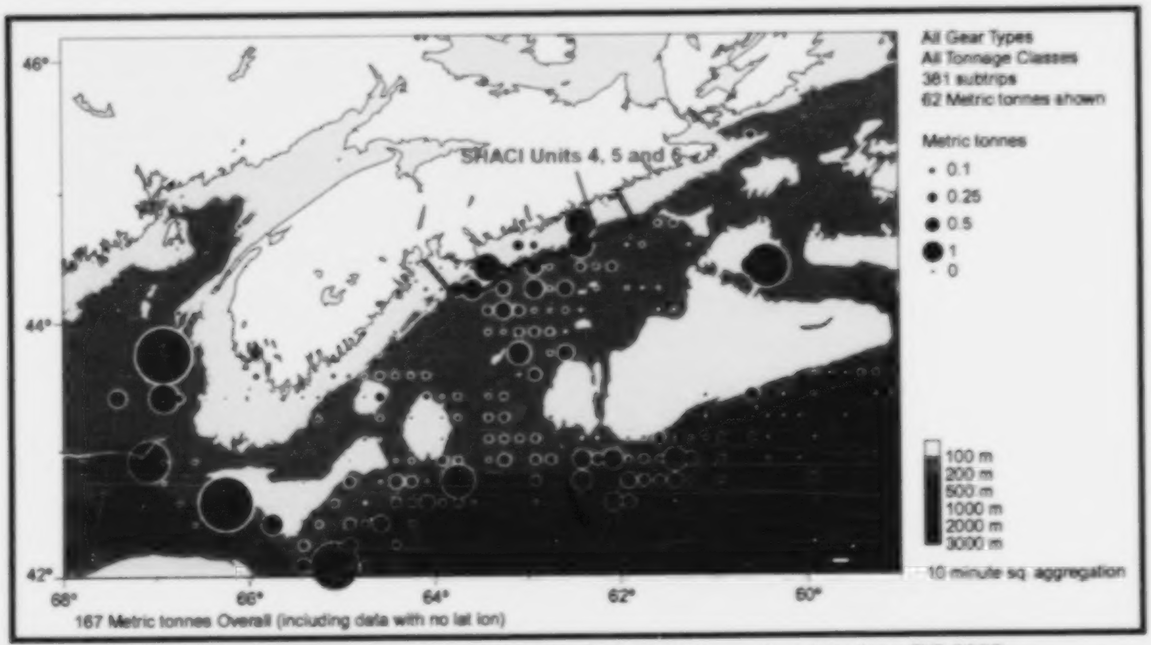

Figure 17-18: Blue shark landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Fishery management plans for blue sharks in Atlantic Canada have maintained non-restrictive catch guidelines of 250 mt annually for blue shark in the directed shark fishery since 1995 (Campana et al. 2004). There are no restrictions on shark caught as bycatch in large pelagic fisheries. Fishing gears in the directed fishery are restricted to longline, handline or rod and reel for commercial licenses, and to rod and reel only for recreational licenses. The recreational fishery is limited to hook and release only. Although the catch and release fishery is designed to return all sharks to the water while alive, some level of hooking mortality is inevitable (Campana et al. 2004).

The Northwest Atlantic porbeagle population was fished intensively at catch levels of approximately 4500 t per year in the early 1960s until the fishery collapsed six years later (Campana et al. 2003). The population slowly recovered during the 1970s and 1980s when annual landings averaged 350 t. Population abundance was again reduced during the 1990s when catches were 1000-2000 t. Since 1961, all indicators of population size have declined substantially, and current population size is estimated at 10-20% of the virgin 1961 population. Fishing mortality is the primary cause of the decline in population since 1961. However, this decline in abundance has ceased, is reversible and, at current fishing quotas, the population will increase at a rate of 2.5% per year (Campana et al. 2003).

Porbeagle sharks are harvested using longlines, usually at depths from 50–150 m, using squid as bait. This fishery occurs mainly in the spring and fall. Prior to 1997, non-restrictive guidelines of 1500 t for porbeagle sharks in Atlantic Canada were established by fishery management plans (O'Boyle et al. 1996). For 1997-1999, a provisional TAC of 1000 t was set, based on historic catches and the decline in recent catch rates (O'Boyle et al. 1998). Based on recent stock assessments, the TAC for porbeagle shark in Atlantic Canada was reduced to 250 t in 2001 (DFO 2002c).

In 4Wk, average porbeagle shark landings between 1995 and 2002 (45 t) contributed fourth-most to total pelagic fish landings (Table 17-13). Dogfish landings make up the greatest amount of shark landings in 4Xm (Table 17-14) (ZIF 2005). In SHACI Units 4-6, average porbeagle shark landings contributed fourth-most to total pelagic fish landings between 1995 to 2002 (Table 17-15). Porbeagle shark landings in SHACI Units 4-6 are shown in Figure 17-19.

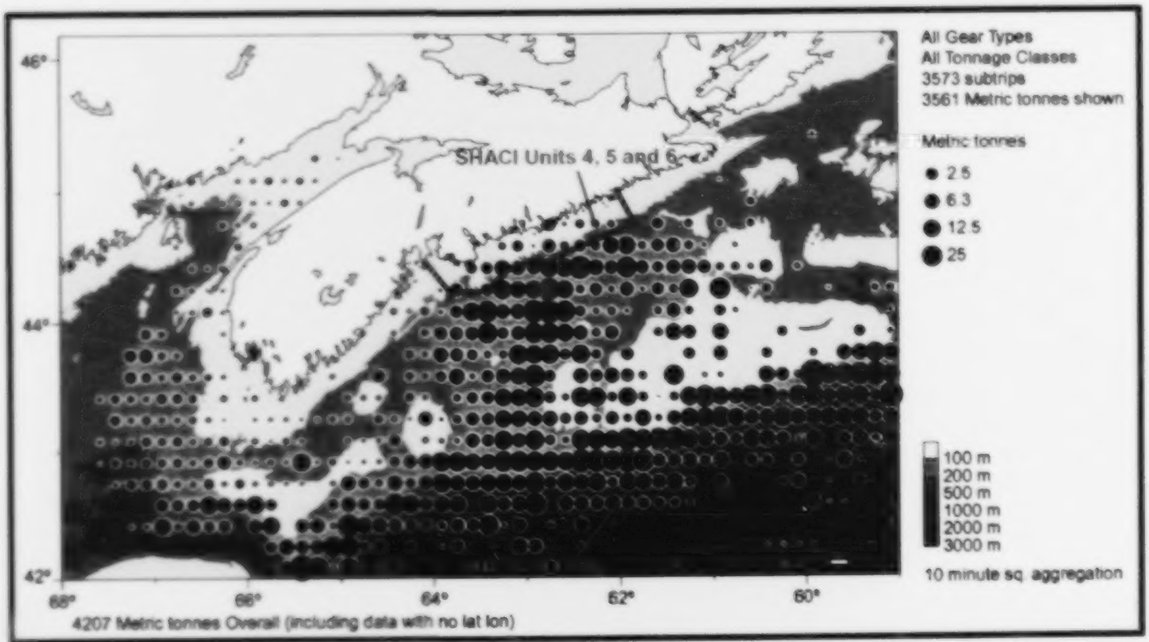

Figure 17-19: Porbeagle shark landings in SHACI Units 4-6 (1995-2002) (based on data from ZIF 2005).

Diadromous fish

With the exception of salmon, the diadromous fisheries are managed by DFO as different statistical districts. Those found within SHACI Units 4, 5 and 6 include statistical districts 18–23, and parts of 17 and 25 (Figure 17-3). Landings by statistical districts were unavailable for analysis in this report. Instead, the data presented is taken from the ZIF (2005), and is organized by NAFO fishery divisions. This data set is known to be incomplete with respect to diadromous species fisheries but can provide some insight into catches.

Of the diadromous species fished in 4Wk and 4Xm, gaspereau (alewife) make up the majority of the landings, followed by eel, smelt and shad (Tables 17-13 and 17-14). With the exception of rainbow smelt, average diadromous fish landings since 1995 have been higher in 4Xm than in 4Wk (ZIF 2005).

Atlantic salmon

Salmon are managed within Salmon Fishing Areas (SFAs). SHACI Units 4, 5 and 6 lie within SFAs 20 and 21 (Figure 17-20). The commercial fishery for Atlantic salmon closed in Atlantic Canada in 1984. Since then, only First Nations and recreational salmon fisheries have been permitted in SFA 20 and 21 (DFO 1998c). First Nations peoples are given first access to salmon (after conservation requirements) based on communal needs for food, social and ceremonial purposes. Atlantic salmon in-river fisheries in the Maritimes have undergone progressive closures due to the persistent failure to achieve conservation requirements (DFO 2002d).

In 1997, only hook-and-release angling was permitted in SFA 20 rivers, with the exception of East River Sheet Harbour where limited grilse harvesting was permitted because the river was being supported with hatchery fish. Native Council of Nova Scotia was signatory to a fishing plan permitting them to issue grilse tags; Millbrook First Nation had a 50 grilse harvest quota for the East River, Sheet Harbour, and Indian Brook First Nation, a 100 grilse harvest quota for the Musquodoboit River. Nonetheless, First Nations did not harvest any Atlantic salmon in SFA 20 in 1997 (DFO 1998c).

Sportcatch of salmon in 1997 in SFA 20 was the lowest since record keeping began in 1951. Coincident with the lower catch, angler effort also declined. This low angler effort was presumably caused in part by the mandatory hook and release regulations that came into effect in 1997 (O'Neil et al. 1998).

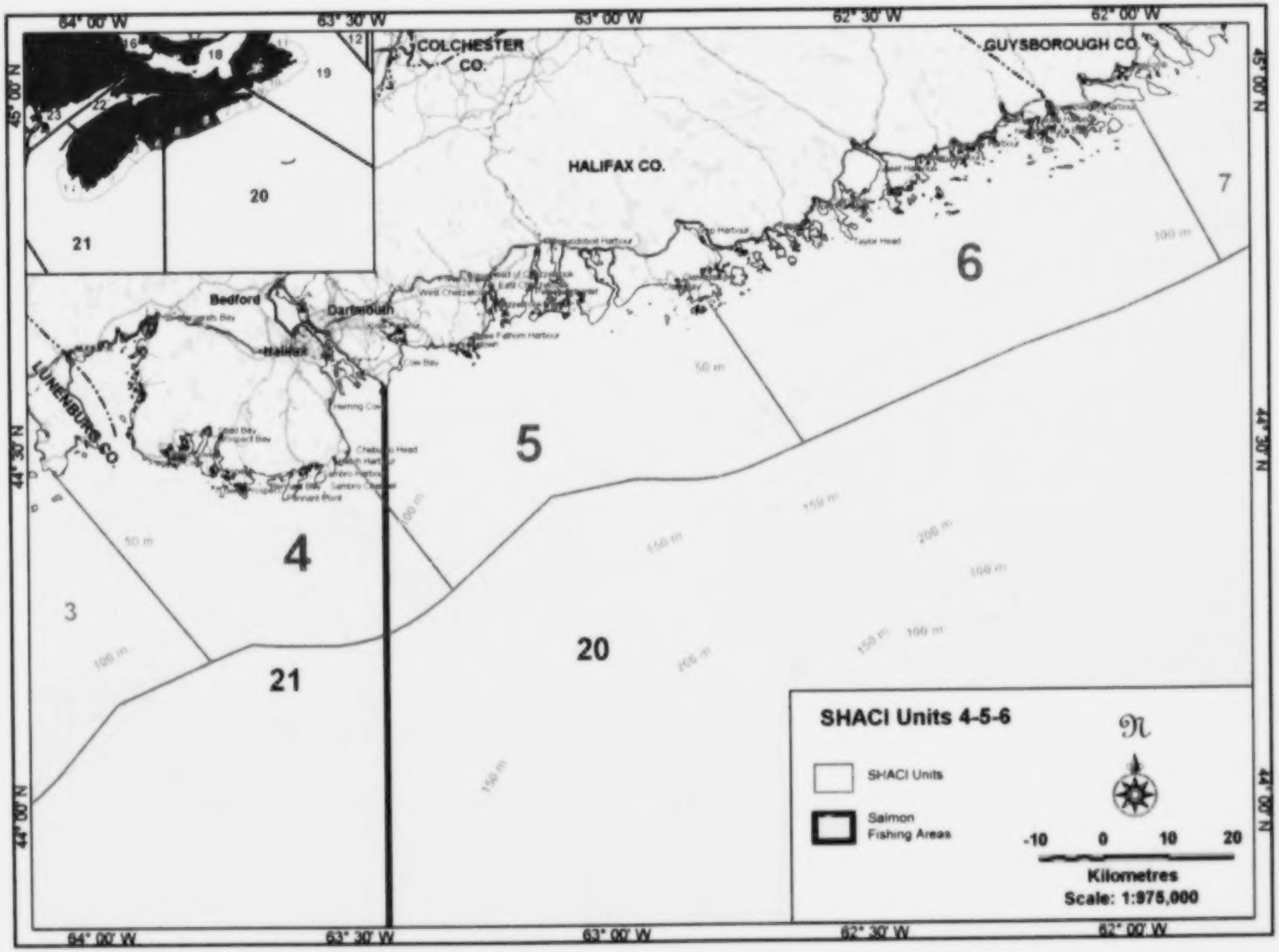

Figure 17-20: Salmon fishing areas (SFAs) 20 and 21 (DFO). Basemap layers (NSGC).

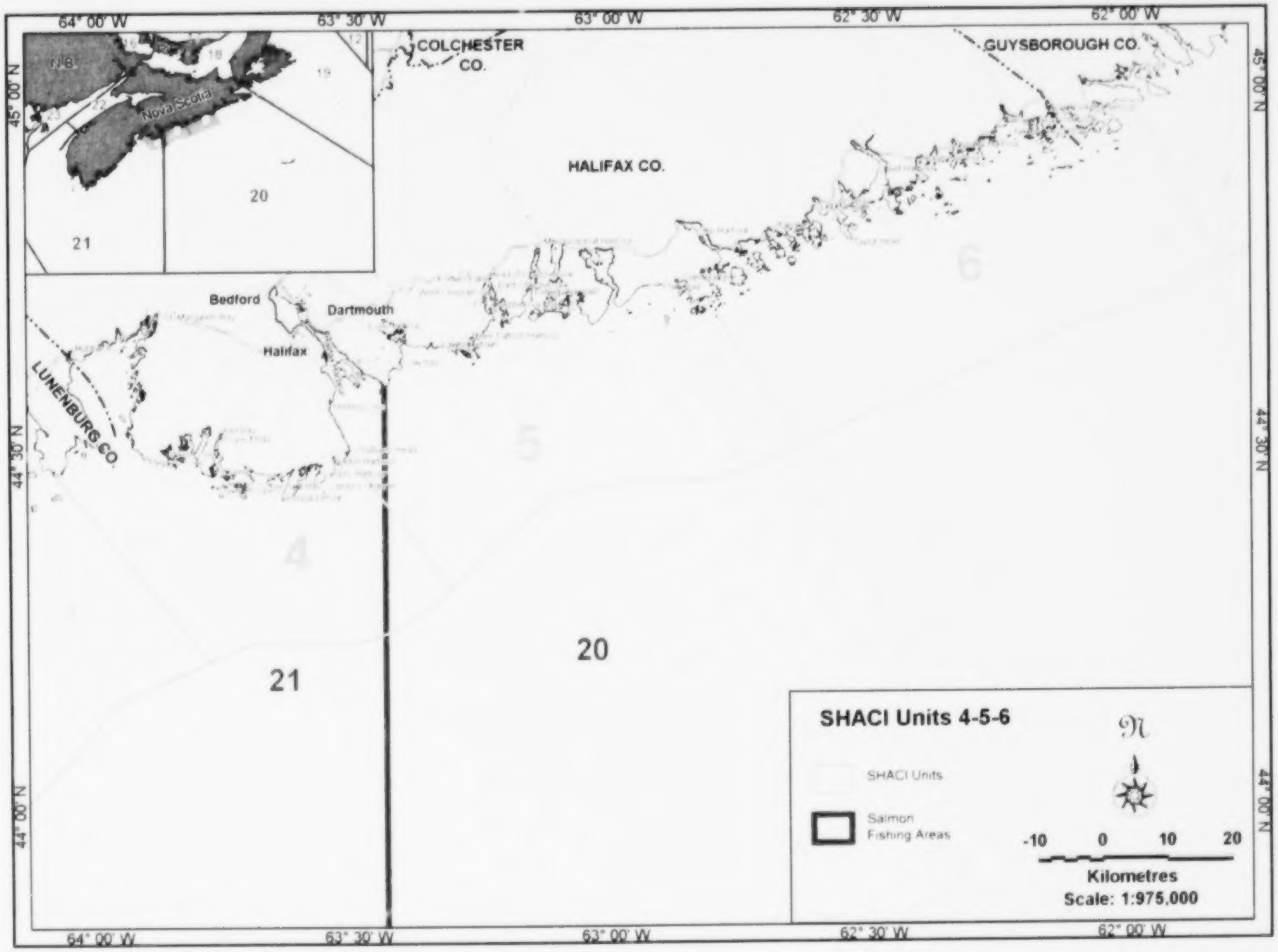

Figure 17-20: Salmon fishing areas (SFAs) 20 and 21 (DFO). Basemap layers (NSGC).

Gaspereau

Gaspereau are listed as alewife in Tables 17-13 and 17-14. Since 1995, gaspereau in 4Xm and 4Wk have been fished most commonly in the spring (April–June). Winter landings (November-March) are also occasionally reported. Gaspereau landings are reported from both set and drift gillnets, otter trawls and traps. Stone et al. (1992) reported the use of various types of wooden traps with wings extending into the river channel, and the use of dip nets in the Ship Harbour and Little West Rivers along the eastern shore.

In 4Wk, gaspereau landings have decreased steadily since 1995, and have averaged roughly 27 t annually. Gaspereau landings have fluctuated more, but are higher in 4Xm; the average landings between 1995 and 2002 being approximately 60 t (Table 17-13). Stone et al. (1992) report that gaspereau are used as lobster bait or for human consumption, depending on the area of Nova Scotia and the timing.

Along the Atlantic coast of Nova Scotia, gaspereau landings are generally expected to remain near current levels, which in most rivers, is below the long term mean (DFO 2001c). The major fishing areas along the Atlantic coast lie southwest of SHACI Units 4, 5 and 6. Minor fisheries do occur east of Halifax within the study area of this report.

Season, gear and license restrictions are used to regulate the gaspereau fishery. The primary restrictive measures used include limiting licenses to existing levels and weekly closed periods. River specific management plans may also include variation from general closures and other restrictions. Logbooks issued to fishermen with licenses are used to collect catch and fishing effort data by individual river and gear type (DFO 2001c). Unfortunately this information was not accessible during the time this report was being prepared.

American eel

In 4Wk, American eels are fished between February and November, while in 4Xm, eels are fished between April and November. The gear used to catch eels in both areas is not well described in landings information, but does include eel traps. Average eel landings since 1995 are only slightly higher in 4Xm (8 t) than in 4Wk (7 t) (Tables 17-13 and 17-14) (ZIF 2005).

In the past, eels were commercially harvested in Ecum Secum, Mosers River, Spry Harbour, Ship Harbour, Port Dufferin, Sheet Harbour Passage, Mushaboom, Musquodoboit Harbour, East Petpeswick Harbour and Pleasant Point (Eales 1966). During the 1960s, eel fishing in many of these areas was low with some uncertainty as to cause. There were reports of a lack of large eels and the presence of a mysterious disease causing eel die-off in certain rivers but Eales (1966) concluded that the poor market price for eels was the main reason for low eel catches at this time.

Rainbow smelt

In Nova Scotia, rainbow smelt are caught both commercially and recreationally. In some areas, the recreational harvest may exceed the commercial harvest but the quantities of recreational harvests are unknown. Catches in Nova Scotia peaked in 1967. Recently, substantial catches were reported in only a few Fisheries Statistical Districts (FSDs), and in formerly productive areas, catches have declined to very low levels (Jessop 1993).

There is a small rainbow smelt fishery in SHACI Units 4, 5 and 6. Average rainbow smelt landings since 1995 are considerably higher in 4Wk (2 t) than in 4Xm (0.3 t) (Tables 17-13 and 17-14) (ZIF 2005). As a historical comparison, in 1966, smelt landings of 28 t were reported in FSDs 17-24 and 25 (roughly SHACI Units 4, 5 and 6) (Jessop 1993).

In both areas 4Wk and 4Xm, smelt is fished over the winter months between October and March. Smelts are caught using the following gear types: set and drift gillnets, traps and otter trawls. Traps are more commonly used in 4Xm, and set gillnets are more commonly used in 4Wk (ZIF 2005). Based on the number of commercial and recreational licenses issued, the major smelt fishing areas within SHACI Units 4, 5 and 6 are within FSD 17, 19, 20 and 25 (Figure 17-3) (Jessop 1993).

American shad

The shad fishery in SHACI Units 4, 5 and 6 is very small. Average landings since 1995 were 0.3 t in 4Wk and 0.4 t in 4Xm. Shad are caught in this area between May and October using both set and drift gillnets, handlines and otter trawls, however, set gillnets catch the most shad.

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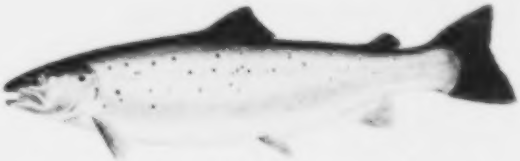
18 - Aquaculture

The coastline of the Halifax Regional Municipality (HRM) is characterized by many bays and estuaries. These areas support naturally high biological productivity, protection from heavy seas and good tidal flushing, making them ideal locations for aquaculture (Davis and Browne 1996). The ongoing decline in traditional fisheries yields and increasing consumer demand for seafood make aquaculture an important source of shellfish and finfish for human consumption, as well as a potentially lucrative industry (Beveridge et al. 1997). Nova Scotia's clean waters, warm in some locations and cold in others, help the aquaculture industry to grow a variety of finfish and shellfish species along this shore, including American oysters, salmonids, blue mussels and limited production of scallops and European oysters (NSDAF 2001a). Land-based and U-fish (stocked pond) operations also produce salmonids, as well as striped bass which is still in the experimental/development stage (NSDAF 2003). These operations, however, by virtue of their terrestrial nature, are largely independent of the coastal environment, and from the perspective of coastal planning, may be less significant and/or controversial than marine-based aquaculture sites.

Species summaries

Aquaculture operations operate like farms in an aquatic environment, and like terrestrial farms, their success is predicated on adequate knowledge of, and appropriate provisions for, the basic biological requirements of cultured organisms at each stage of their life history. The following pages profile the biology, life cycle, feeding habits, growing techniques and farming areas of eight of the more commonly produced species within HRM. The reader is encouraged to consult with the Nova Scotia Department of Agriculture and Fisheries for the most up-to-date aquaculture licenses and sites.

Atlantic salmon (Salmo salar)



The Atlantic salmon has a long and laterally compressed body, a large mouth, large scales and a fleshy adipose fin on the back just in front of the tail fin. Average adult weights range between 2 and 10 kg, although they may grow much larger. These fish go through a number of different life stages, all of which have bearing on the production life cycle of a salmon aquaculture operation.

Salmon eggs are produced in a hatchery in November and incubated at varying water temperatures. In late winter or early spring they hatch as sac fry, begin to feed on special starter diets, and are kept in tanks designed for feeding. Once they reach a sufficient size, the salmon are graded for uniformity and size, and transferred to rearing tanks in May or June. They are now at the parr stage and feed throughout the summer, until fall, when they are graded again to select potential smolt. When smolts have reached a weight of about 80 g the following spring, they are transferred to saltwater and placed in sea cages (net enclosures supported by floating frames made of plastic, steel, aluminium and wood). They are fed a special diet of fish meal and fish oil until they reach market size, between 2-5 kg. This is usually 14-18 months later, or about 2 ½ years after the eggs were first collected. Since Atlantic salmon require relatively warm water throughout the winter, only selected areas in Nova Scotia are suitable for year round production; St. Margarets Bay is typically considered the only suitable embayment within SHACI Units 4-6, although one such farm currently licensed in the mouth of Ship Harbour. Five Atlantic salmon aquaculture sites are currently licensed within the study area (Figures 18-1 and 18-2) (NSDAF 2001b, NSDAF 2003, NSDAF 2005).

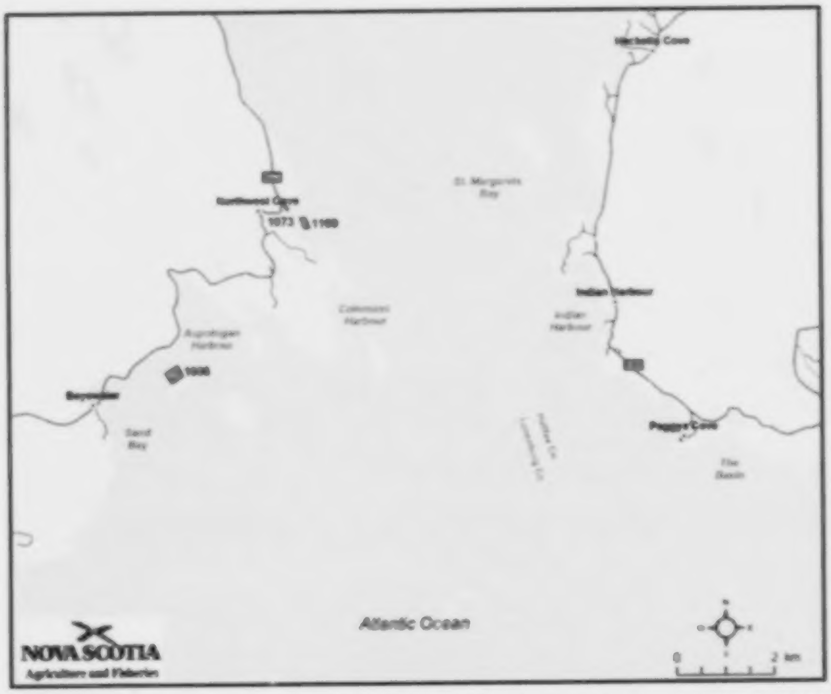


Figure 18-1: Atlantic salmon (leases 1006, 1073 & 1169), steelhead salmon (leases 1006, 1073 & 1169) Atlantic cod and Atlantic halibut (lease 1006) aquaculture sites in western St. Margarets Bay (NSDAF 2005)

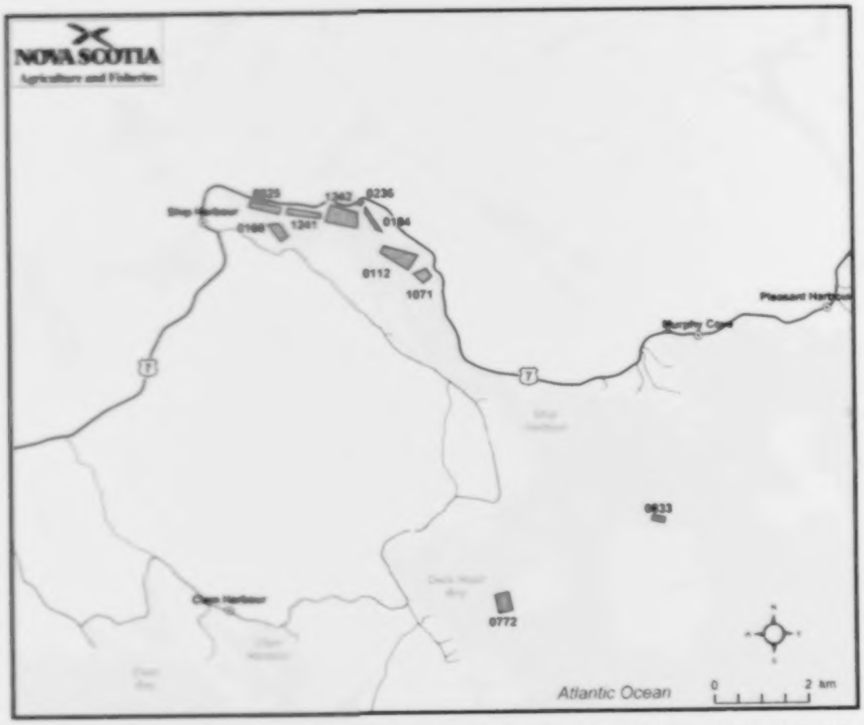


Figure 18-2: Atlantic salmon (leases 0772 & 0833), steelhead salmon (leases 0772 & 0833), blue mussel (leases 1071, 0112, 0184, 0236, 1242, 1241, 0025 & 0168), sea scallop (leases 0184, 1242, 1241 & 0025), & European oyster (1242, 1241 & 0025) aquaculture site leases in Ship Harbour (NSDAF 2005)

Steelhead salmon (Oncorhynchus mykiss)

Steelhead salmon are actually rainbow trout that are raised in saltwater. Steelhead have a long body and their colouring ranges from bluish to yellow-green, brown or black. They are characterized by a silvery sheen which serves as the origin of their name. These finfish are native to the west coast and are a relative of the west coast salmon. They were first introduced in1899 and have been grown on the east coast for over 30 years. In the wild, rainbow trout migrate to saltwater from freshwater streams and return to freshwater to spawn when they are mature.

Steelhead start their lives in freshwater and are reared similarly to rainbow trout. They are ready to be transferred to saltwater when they reach 100 g, although some aquaculturists wait until the fish reach 450 g before the fish are moved to saltwater cages (nylon mesh suspended from a steel, wood, plastic or aluminium collar). Steelhead are transferred in May and go through the final grow-out over the following six to nine months. During this period, steelhead are fed a similar diet to the rainbow trout. This consists mostly of dry food pellets containing 80% fish meal and fish oil with added minerals and vitamins. The diet provides a proper nutritional balance that promotes growth and quality. The cages must be periodically changed or cleaned of fouling organisms (seaweeds, mussels) which block the flow of water through the cage. Harvesting occurs between September and December at which time the fish weigh 1-3 kg. Steelhead salmon are licensed to be grown at several sites along the Eastern Shore of Nova Scotia, with six sites in SHACI Units 4-6 (Figures 18-1, 18-2, 18-3) (NSDAF 2001c, NSDAF 2003, NSDAF 2005).

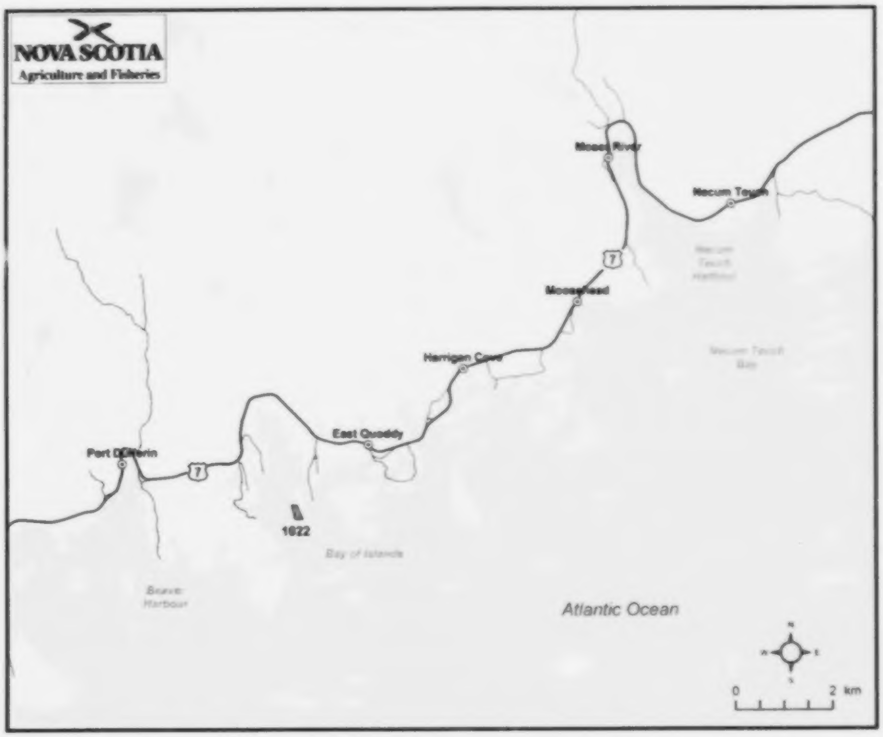


Figure 18-3: Steelhead salmon aquaculture site (lease 1022) in Quoddy Harbour (NSDAF 2005)

Rainbow trout (Onorhynchus mykiss)

This fish, well known for its ability to adapt to different conditions, was first introduced to Nova Scotian waters in 1899. The size of the rainbow trout varies but in Atlantic Canada the average weight is 0.5-1 kg. It has a long, slender body, with an iridescent band running along each side from head to tail. The overall body colour can range from bluish to yellow-green, brown or black.

The farming life cycle begins with harvesting eggs from selectively bred spawners. Once the eggs are fertilized, they are placed in incubator tanks for hatching, where the rate of growth is controlled mainly by water temperature. There are a number of incubator units, including troughs, combi-tanks, stacked tray units, jars and baskets. After they hatch, they are called sac-fry and remain in the tanks, living off the energy reserves in the yolk sacs attached to their bellies. After four to six weeks, the fry are fed a special diet of commercial food pellets, similar to that of salmon, containing 80% fish meal and fish oil with minerals and vitamins added. This provides proper nutritional balance geared toward growth and product quality. Grown in these tanks to a weight of 1-5 g, the fish are then transferred to rearing units, where they grow through the fingerling stage until they reach market size. A number of methods are used for final grow-out; facilities may include earthen ponds, cages in ponds, rectangular or circular tanks, or concrete raceways. The grow-out period usually takes between 12 and 18 months, with harvest size generally between 284 and 397 g, commonly referred to as "pan-sized." Rainbow trout products are sold fresh whole, as fillets and smoked.

There are numerous hatcheries and grow-out ponds in Nova Scotia but none are currently active in the HRM. Hatcheries and grow-out sites must have adequate water supplies to be successful. These operations supply rainbow trout for U-fish or retail markets, as well as seed stock for marine grow-out sites (NSDAF 2001d).

Blue mussels (Mytilus edulis)

Mussels are bivalve shellfish that grow quickly and profusely, two traits that make them ideal for aquaculture. They have two identical, convex shells. These shells are elongate, triangular and joined by a rubbery hinge ligament on the upper side. A commercial sized mussel takes 18-24 months to grow to about 50 mm. Mussels usually become sexually mature in late spring or early summer. Following some spawning stimulus, most mussels release some or all of their eggs and sperm in what looks like whitish or orange clouds in the water. Fertilization is external and in a very short time all the eggs are fertilized.

Once fertilized, the embryo quickly develops small cilia and begins to swim. After 48 hours, it develops into a trochophore larva, feeding on small phytoplankton cells and beginning to develop the distinctly D-shaped larval shell. The next stage is the veliger larvae. In 3 to 4 weeks, the mussel grows to a quarter millimetre in size. The larva develops a foot and gills and is ready to change into a juvenile mussel. It settles on a suitable hard substrate, such as a rock, wharf or boat, extends the foot and withdraws the velum. Finally, it secretes byssus threads and anchors itself to the surface where it will grow into a mature mussel.

Mussels are filter feeders, feeding by actively filtering particles from the water. Phytoplankton cells are their main food source which may be supplemented by decomposed macrophytes or resuspended detritus. Mussels cultured in eastern Canada are usually reared on long lines. These are typically 180 m ropes, anchored securely at both ends, and supported by floats tied at intervals along their length. Growers generally use concrete for anchors and mussel buoys for floats. Mussel farmers need lots of seed for a satisfactory harvest. Hundreds of plastic mesh or rope collectors are hung on the long lines just before the spat are expected to settle in the early summer. By fall, most settled spat have grown to about 15 mm. They are then stripped off the collectors and loaded into lengths of mesh tubing called socks. The socks are then taken to the farm and tied at intervals onto another long line where they will grow to market size. This takes 18 months to 3 years, depending on location, water temperature and the availability of plankton.

Mussels grow well in areas of good currents and clean water which is found all along the eastern mainland shore. Blue mussels are the most widely cultured species of any kind along Nova Scotia's Atlantic shore, with 24 sites in SHACI Units 4-6 alone (Figures 18-4, 18-5, 18-6, 18-7, and 18-8) (NSDAF 2001e, NSDAF 2003).

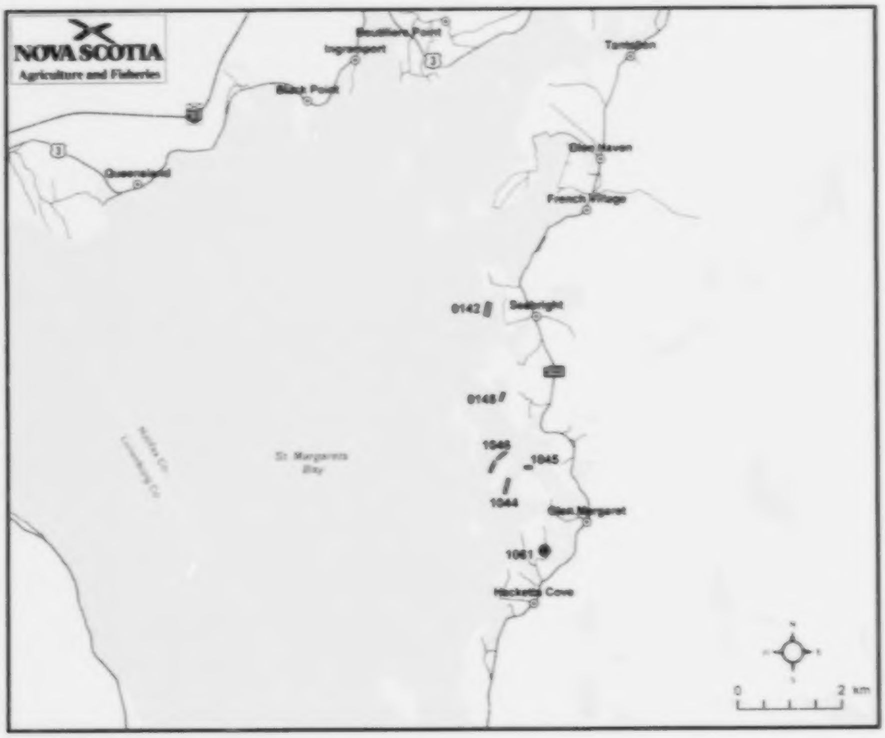


Figure 18-4: Blue mussel (leases 0142, 0145, 1044, 1045 & 1046), sea scallop (leases 0142, 1044, 1045 & 1046), and European oyster (leases 0142, 0145, 1044, 1045 & 1046) aquaculture sites and speckled trout U-Fish (lease 1061) in eastern St. Margarets Bay (NSDAF 2005)

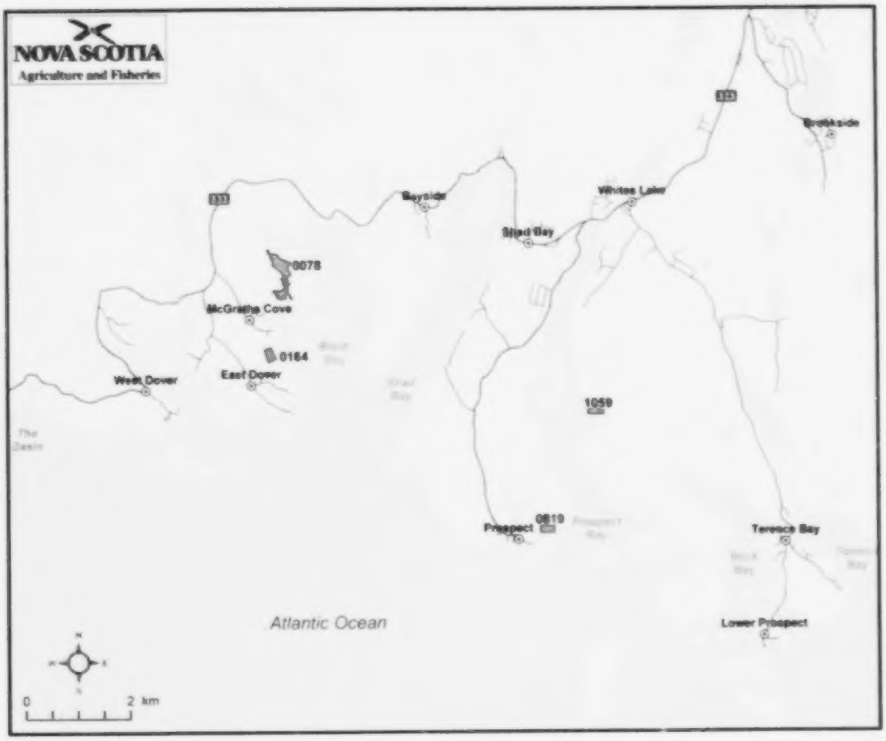


Figure 18-5: Blue mussel (leases 0164, 0078, 0819, & 1059), sea scallop (leases 0164 & 0078), and European oyster (leases 0164, 0078 & 0819) aquaculture sites and speckled trout U-Fish (lease 1061) in Blind Bay and Prospect Bay (NSDAF 2005)

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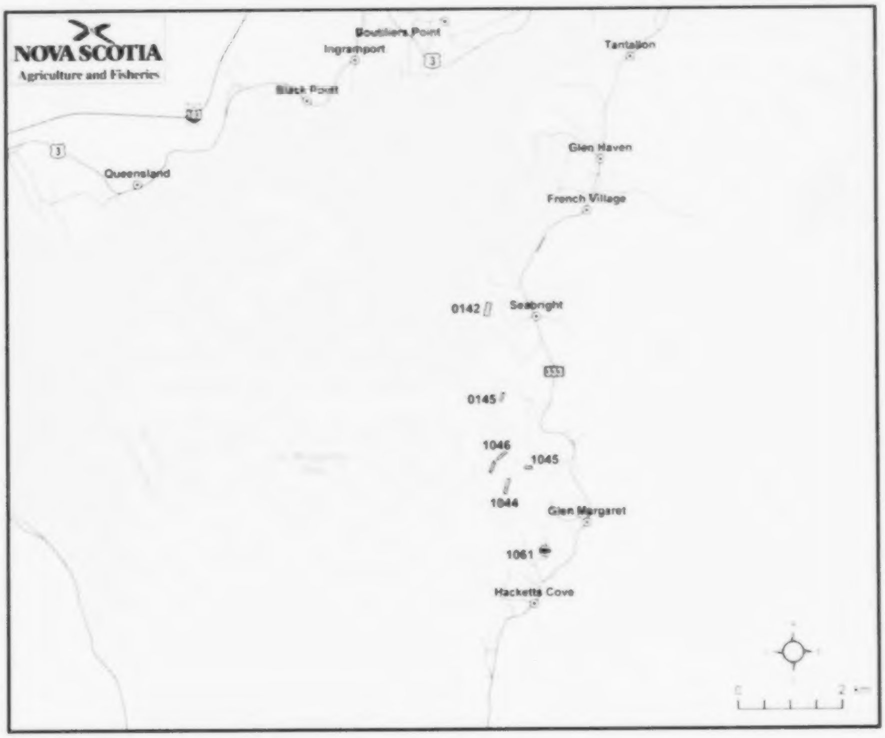


Figure 18-4: Blue mussel (leases 0142, 0145, 1044, 1045 & 1046), sea scallop (leases 0142, 1044, 1045 & 1046), and European oyster (leases 0142, 0145, 1044, 1045 & 1046) aquaculture sites and speckled trout U-Fish (lease 1061) in eastern St. Margarets Bay (NSDAF 2005)

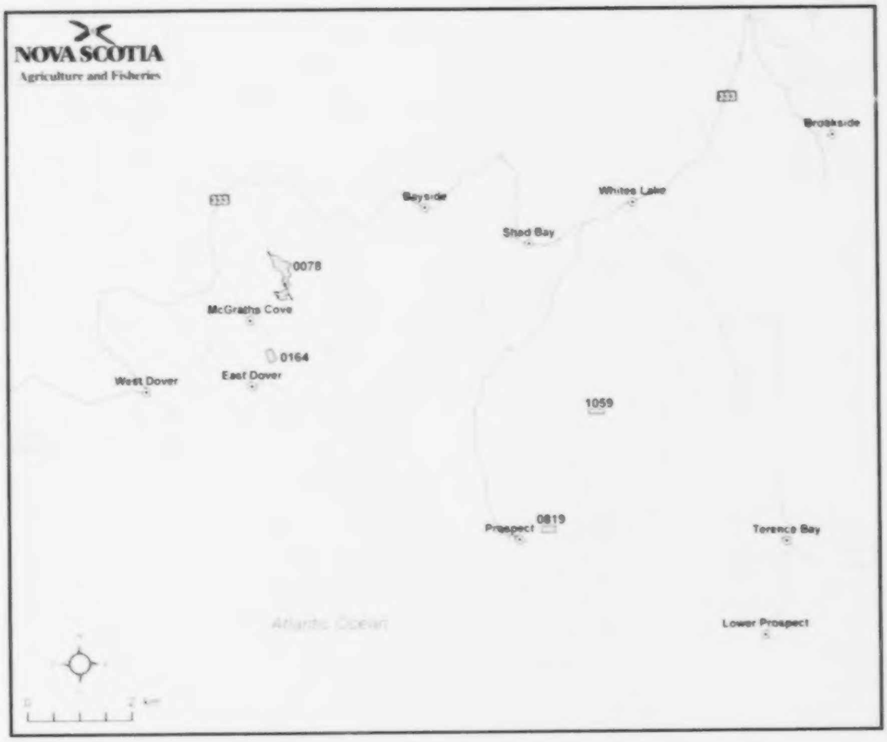


Figure 18-5: Blue mussel (leases 0164, 0078, 0819, & 1059), sea scallop (leases 0164 & 0078), and European oyster (leases 0164, 0078 & 0819) aquaculture sites and speckled trout U-Fish (lease 1061) in Blind Bay and Prospect Bay (NSDAF 2005)

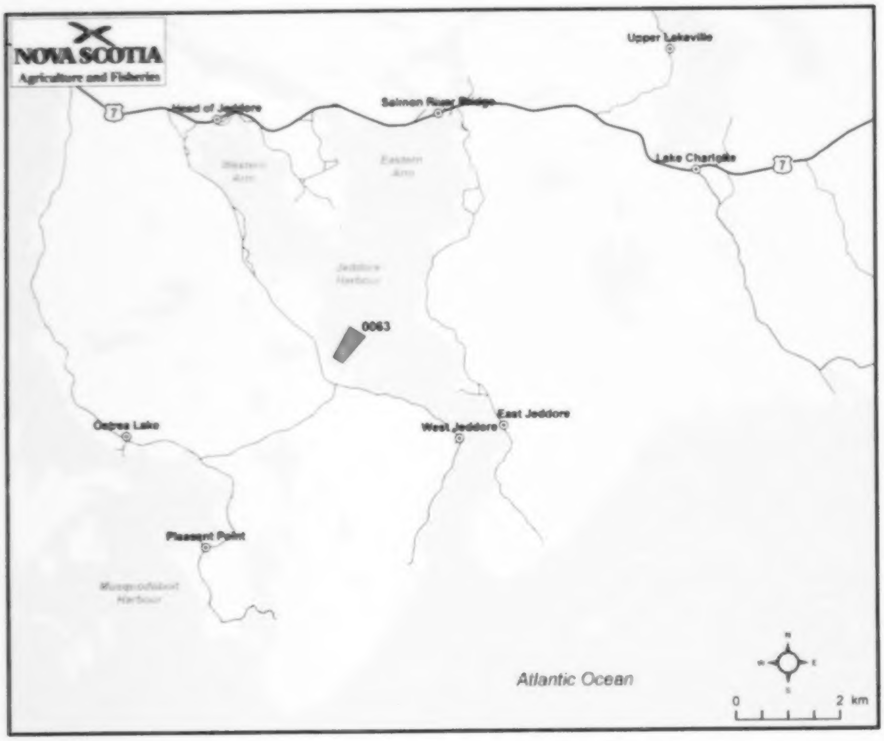


Figure 18-6: Blue mussel (lease 0063) aquaculture sites in Pond and Jeddore Harbour (NSDAF 2005)

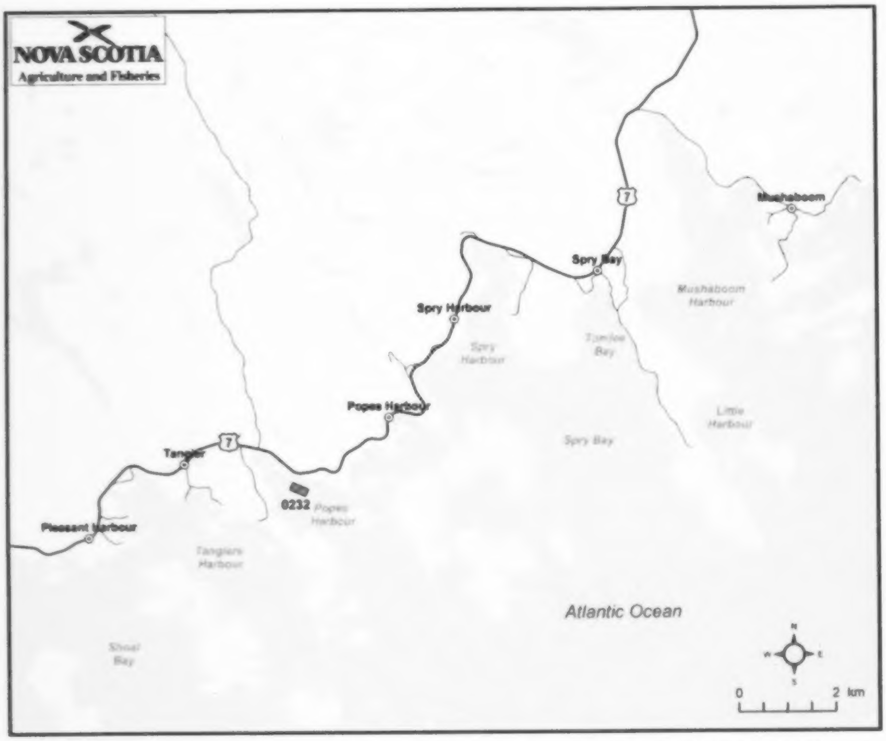


Figure 18-7: Blue mussel aquaculture site (lease 0232) in Popes Harbour (NSDAF 2003)

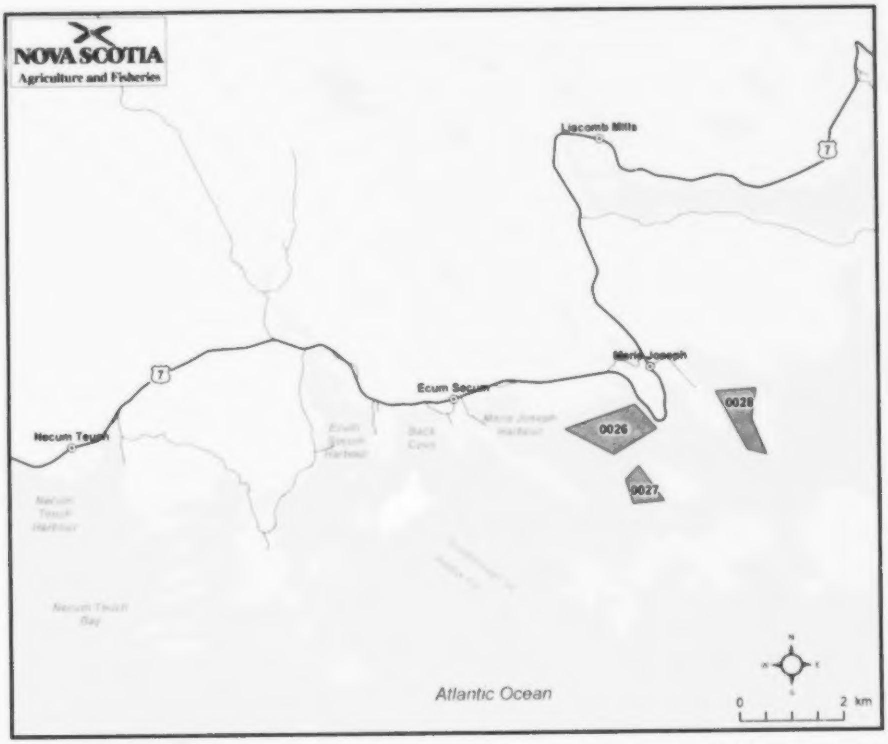


Figure 18-8: Blue mussel (leases 0026, 0027 & 0028) and sea scallop (lease 0027) aquaculture sites in Marie Joseph Harbour (NSDAF 2005)

Sea scallops (Placopecten magellanicus)

Sea scallop. With permission of the Marine Biological Laboratory.

Sea scallops are bivalves, with two valves or shells that are both round, almost equal in diameter, and held together by a small, straight hinge and the adductor muscle. The lower valve is white or cream in colour and the upper is usually reddish. Inside these shells is the "meat" (the adductor muscle) which is the part of the scallop commonly eaten in North America. Sea scallops usually spawn in late summer or early fall. Eggs and sperm are released in what looks like a white or orange cloud in the water. Fertilization of the eggs is external.

Shortly after fertilization, the embryo develops small cilia and starts to swim. After 48 hours, it develops into a trochophore larva, feeding on small phytoplankton cells and beginning to develop the distinctly D-shaped larval shell. At this stage the scallop is called veliger larva and it swims, feeds and grows. In four to five weeks it reaches the pediveliger stage and is 0.4 mm long. It finds a place to settle, anchors itself securely and grows into a mature scallop.

In shellfish farms, sea scallops feed on phytoplankton and other particles. The food is captured by the gills and transferred by the labial palps (located at the forward end of the gills) to the gut where it is sorted for digestion.

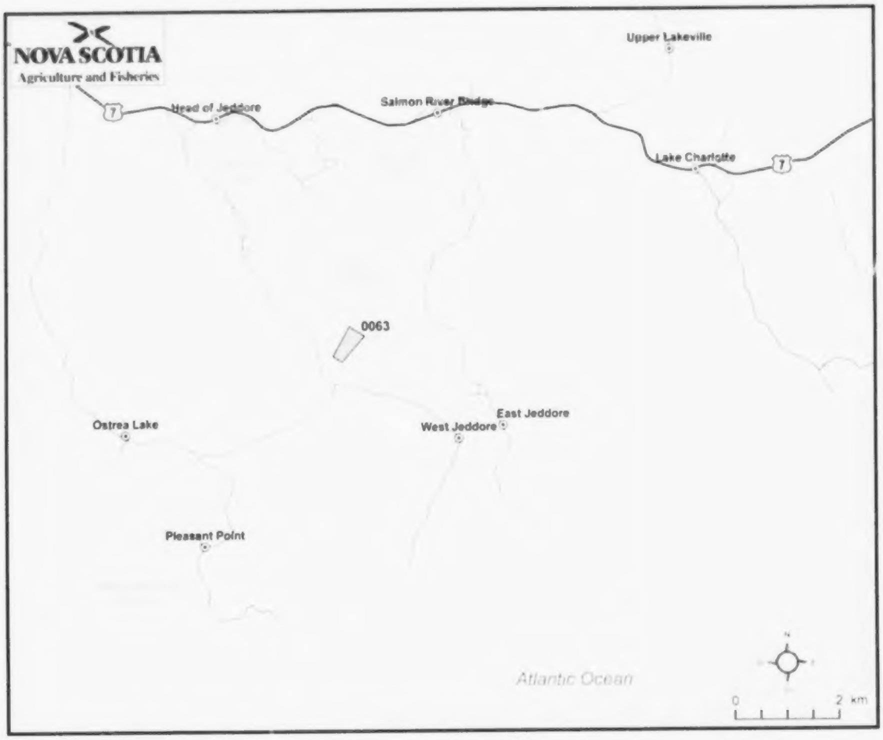


Figure 18-6: Blue mussel (lease 0063) aquaculture sites in Pond and Jeddore Harbour (NSDAF 2005)

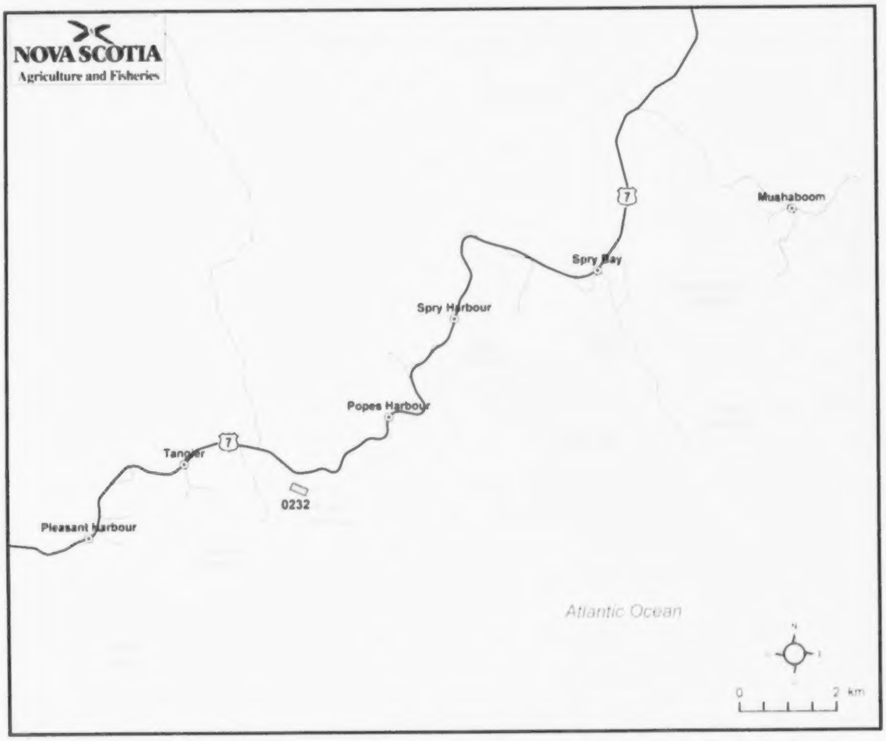


Figure 18-7: Blue mussel aquaculture site (lease 0232) in Popes Harbour (NSDAF 2003)

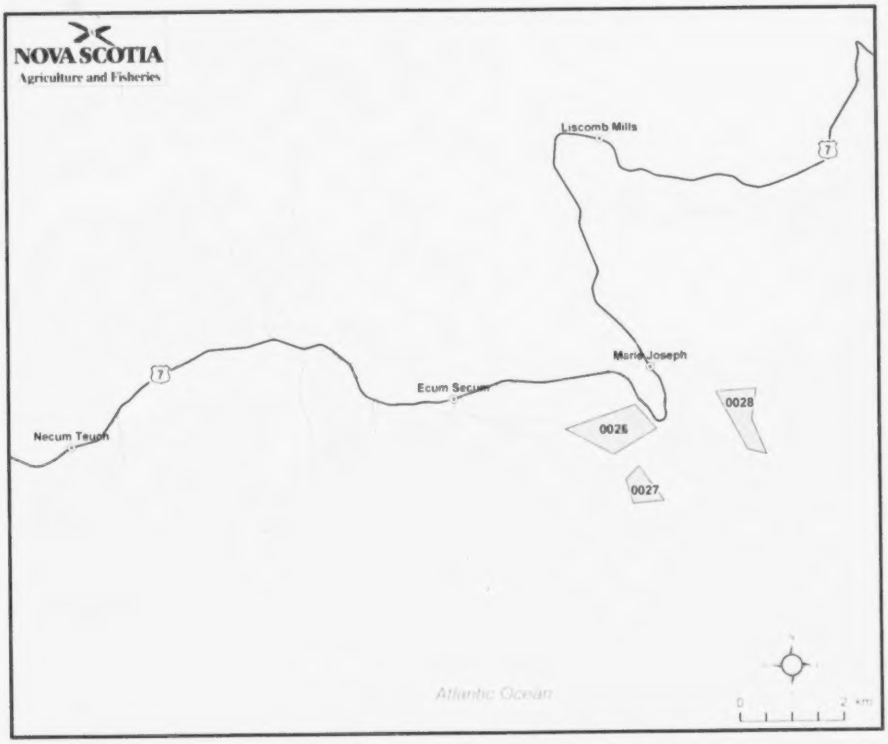


Figure 18-8: Blue mussel (leases 0026, 0027 & 0028) and sea scallop (lease 0027) aquaculture sites in Marie Joseph Harbour (NSDAF 2005)

Sea scallops (Placopecten magellanicus)

Sea scallop. With permission of the Marine Biological Laboratory

Sea scallops are bivalves, with two valves or shells that are both round, almost equal in diameter, and held together by a small, straight hinge and the adductor muscle. The lower valve is white or cream in colour and the upper is usually reddish. Inside these shells is the "meat" (the adductor muscle) which is the part of the scallop commonly eaten in North America. Sea scallops usually spawn in late summer or early fall. Eggs and sperm are released in what looks like a white or orange cloud in the water. Fertilization of the eggs is external.

Shortly after fertilization, the embryo develops small cilia and starts to swim. After 48 hours, it develops into a trochophore larva, feeding on small phytoplankton cells and beginning to develop the distinctly D-shaped larval shell. At this stage the scallop is called veliger larva and it swims, feeds and grows. In four to five weeks it reaches the pediveliger stage and is 0.4 mm long. It finds a place to settle, anchors itself securely and grows into a mature scallop.

In shellfish farms, sea scallops feed on phytoplankton and other particles. The food is captured by the gills and transferred by the labial palps (located at the forward end of the gills) to the gut where it is sorted for digestion.

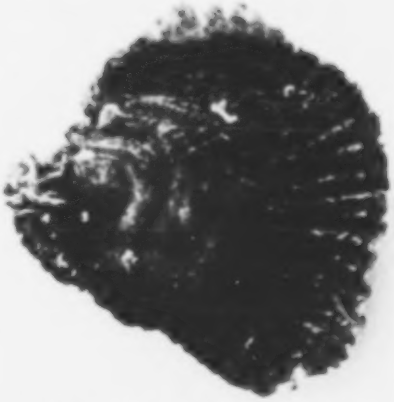
Growing Techniques
Sea scallop farming is a process that goes through certain steps. First spat are collected from the wild or from hatcheries. The juvenile scallops are then grown on long lines using fine mesh lantern nets or pearl nets suspended in the water column. A number of methods can be used, including lantern nets, a technique which involves passing loops through small holes drilled in the outer edge of the scallop shell and hanging them from the long line. Growth varies from site to site but with suspended culture, scallops usually take 18 months to two years to grow to market size. Sea scallops grow well in similar environmental conditions to those required by mussels, and are likewise commonly cultured within SHACI Units 4-6 (Figures 18-2, 18-4,18-5 and 18-8) (NSDAF 2001f).

American oyster (Crassostrea virginica)

{PRIVATE "TYPE=PICT;ALT=American Oyster"}Native to the North American coast from the Gulf of Mexico to northern New Brunswick, this hardy species can live in a range of temperatures from -2°C to 32°C. It has a thick shell with a rough, sculptured appearance and varies in colour. Usually it is a mixture of brown, grey, green and white shades. Most American oysters take between four and seven years to reach market size. American oysters spawn in summer when the water warms up to above 20°C. The oysters release eggs and sperm into the water at intervals over a period of four to six weeks. The eggs become fertilized in the open water, subsequently developing into microscopic larvae that form shells and develop organs to help them swim and feed. For the next three weeks, the larva swims and feeds on microscopic plants in the plankton community. Soon the oyster reaches the size of a grain of pepper and searches for a place to settle. It then attaches itself and remains there to grow into a mature oyster. Adult oysters feed primarily on plankton; when water conditions are favourable, they do so almost continuously.

Bottom and off-bottom culture are commonly used techniques in the Maritimes. Off-bottom culture uses cages, floating long lines. Cultch (a substance used to attach spat) is strung like beads on wire or nylon rope. This wire or rope is then suspended above the bottom to collect the setting larvae. The collected spat are grown in suspension until they reach the desired length. Finally, they are separated from the cultch and either planted on the bottom or placed on trays that are suspended in the water. Held in suspension, the oysters grow quickly and develop plumper meats than those that are bottom grown (NSDAF 2001g). The requirement for warm (>20°C) water temperatures for spawning severely restricts the areas where oysters occur naturally. Natural populations are restricted to the Bras d'Or Lakes, northern Nova Scotia and a few pocket populations on the eastern seaboard.

European oyster (Ostrea edulis)



{PRIVATE "TYPE=PICT;ALT=European Oyster"}The European oyster was first introduced to Nova Scotia in 1973. The shell is similar to the American oyster but flakier in texture and more evenly rounded with a wavy edge. The European oyster is pinkish white in colour, sometimes with purplish pink margins.

European oysters are usually ready to spawn when they are two years old. Spawning is seasonally controlled and gonad (reproductive gland) development occurs in late spring. A unique feature of this species is its ability to develop both male and female gonads in the same spawning season. If food remains available and temperature is adequate, an oyster may develop eggs after having spawned as a male, or vice versa. When spawning occurs, females retain the eggs within their shells. Males release sperm into the water that is drawn in by the female, after which fertilization occurs.

After fertilization the eggs remain in the female's shell for one or two weeks living off food stored in the egg. When they are about 0.18 mm in size the female releases the larvae and they begin feeding. They continue to feed and develop until they are approximately 0.32 mm in size and ready to set on a suitable surface. The larvae, now called spat, undergo metamorphosis during which they lose some of their larval organs and develop adult organs such as gills. After this change, the juvenile oysters resemble adults and grow according to temperature and the availability of food which they consume by filter feeding.

Growing Techniques
European oyster culture begins in a hatchery. Fertilization takes place in tanks and plastic discs are provided for the larval oysters to set on. About 12 hours after setting on the discs, these juvenile oysters, measuring about 0.35 mm, are scraped off and moved to upweller tanks where they feed on algae. They usually remain here for two or three weeks until they reach 5-15 mm in size. In June the oysters are placed in seed trays in the ocean. They spend 1-2 months growing in these wooden trays until they are 2-5 cm in size. For final grow-out they are placed in lantern nets or mesh bags. It usually takes between 36 and 48 months for oysters to grow from hatchery to market size (NSDAF 2001h). European oysters require both good currents and warm waters for growth, found primarily south of Halifax. European oysters are cultured at 9 sites throughout SHACI Units 4-6 (Figures 18-2, 18-4, 18-5).

Aquaculture locations

Marine fish and shellfish are cultured at 29 sites throughout Units 4-6; 30 of these are distributed among nine coastal embayments and the other site is a land-based U-fish pond. (Tables 18-1, 18-2, 18-3). The majority of marine aquaculture sites are smaller than 10 ha in surface area but range up to 85 ha; the three largest sites are found in Marie Joseph Harbour which also claims the highest total surface area under culture at 170.97 ha. Ship Harbour and St. Margarets Bay together host a total of 18 sites, over 50% of all leases including non-marine sites.

Table 18-1: Aquaculture sites in SHACI Units 4-6 (compiled from NSDAF 2005)

SHACI Unit	Water body	# of sites	Species[1]	# licence holders	Area (Ha)
Unit 4	St. Margarets Bay	8	Atlantic salmon, Steelhead salmon, *Atlantic cod, * Atlantic halibut, Blue mussels, Sea scallops, European oysters	4	20.13
	Blind Bay	2	Blue mussels, European oysters, Sea scallops	2	19.31
	Prospect Bay	2	Blue mussels, European oysters	1	6.80
	U-fish ponds	1	Speckled trout	1	N/A
Subtotal	# of water bodies = 4	13	# = 8	8	46.24
Unit 5	Jeddore Harbour	1	Blue mussels	1	18.43
Subtotal	# of water bodies = 1	1	# = 1	1	18.43
Unit 6	Ship Harbour –head	8	Blue mussels, European oysters, Sea scallops	1	83.88
	Ship Harbour –mouth	2	Atlantic salmon, Steelhead salmon	1	15.34
	Pope's Harbour	1	Blue mussels	1	5.24
	Quoddy Harbour	1	Steelhead salmon	1	3.86
	Marie Joseph Harbour	3	Blue mussels, Sea scallops	2	170.86
Subtotal	# of water bodies = 4**	15	# = 5	6	279.18
Total	# of water bodies = **9**	**29**	# = **8**	**15*****	**343.85**

[1] Species were reported by common name; thus it is impossible to distinguish which species sharing the same common name are cultured at these sites.

* Although site #1006 in St. Margarets Bay is licensed for the culture of both Atlantic halibut and Atlantic cod, these species are currently not farmed at this location. Both species are relatively new to marine-cage aquaculture in this region, but are currently cultured in land-based facilities in other regions of the Province. It is anticipated that both cod and halibut will be farmed in St. Margarets Bay in the near future.

**Although the head and mouth are distinguished above, they are considered part of the same water body.

***One licence holder holds licences in two different water bodies.

Table 18-2: Species production by site (NSDAF 2005).

Species	# of sites	Site licence numbers	Site type
Atlantic salmon	5	0772, 0833, 1006, 1073, 1169	Marine
Steelhead salmon	6	0772, 0833, 1006, 1022, 1073, 1169	Marine
*Atlantic cod	1	1006	Marine
*Atlantic halibut	1	1006	Marine
Speckled trout	1	1061	U-fish
European oysters	9	0025, 0078, 0164, 0819, 1044, 1045, 1046, 1241, 1242	Marine
Blue mussels	22	0025, 0026, 0027, 0028, 0063, 0078, 0112, 0142, 0145, 0164, 0168, 0184, 0232, 0236, 0819, 1044, 1045, 1046, 1059, 1071, 1241, 1242	Marine
Sea scallops	12	0025, 0027, 0078, 0112, 0142, 0164, 0184, 1044, 1045, 1046, 1241, 1242	Marine

* Atlantic cod and Atlantic halibut are not currently being farmed at this location (lease 1061).

Table 18-3: Aquaculture site lease profiles (NSDAF 2005).

Site licence number	Species cultured	Area (Ha)
0025	Sea Scallops; European oyster; Blue mussels	10.16
0026	Blue mussels	84.80
0027	Blue mussels; Sea scallops	29.23
0028	Blue mussels	56.97
0063	Blue mussels	18.43
0078	Blue mussels; European oyster; Sea scallops	17.07
0112	Blue mussels; Sea scallops	20.09
0142	Blue mussels; Sea scallops	2.85
0145	Blue mussels	0.98
0164	Blue mussels; Sea scallops; European oyster	3.72
0168	Blue mussels	8.80
0184	Blue mussels; Sea scallops	4.92
0232	Blue mussels	5.25
0236	Blue mussels	0.85
0772	Atlantic salmon; Steelhead salmon	11.99
0819	Blue mussels; European oysters	3.80
0833	Atlantic salmon; Steelhead salmon	3.35
1006	*Atlantic cod; *Atlantic halibut; Atlantic salmon; Steelhead salmon	7.61
1022	Steelhead salmon	3.86
1044	Sea scallops; European oyster; Blue mussels	1.87
1045	Sea scallops; European oyster; Blue mussels	0.90
1046	Sea scallops; European oyster; Blue mussels	1.41
1059	Blue mussels	3.00
1061	Speckled trout	N/A
1071	Blue mussels	6.78
1073	Atlantic salmon; Steelhead salmon	0.46
1169	Steelhead salmon; Atlantic salmon	2.68
1241	Sea scallops; European oysters; Blue mussels	9.25
1242	Sea scallops; European oysters; Blue mussels	23.01

* Atlantic cod and Atlantic halibut are not currently being farmed at this location (lease 1061).

Opportunities

Softshell clams (*Mya arenaria*) are the focus of a traditional Nova Scotian fishery that has recently been in decline, with variable reported landings and inadequate pricing (Freeman et al. 1996). Studies have shown that the fastest natural intertidal clam growth in Nova Scotia results in a harvestable shell length in 5.4 years (Witherspoon 1982, Mullen and Woo 1985, Woo 1991). Freeman et al. (1996) identified the potential for accelerated growth and a predictable yield of this species through the application of selected aquacultural techniques, including holding clams in trays of sand suspended from rafts, judicious stock selection, hatchery production and a grow-out system

Threats of aquaculture operations

Aquaculture operations can negatively impact the environments they inhabit through high waste production, disproportionately high consumption of natural resources, and steps in the production process itself (Beveridge et al. 1997). Escaped cultured species such as salmon can threaten genetic integrity of wild populations and put them at risk of biological extinctions (Whoriskey 2002), although there is no conclusive evidence of this in Nova Scotia (Doubleday, 2001). The aquaculture industry can also socially impact communities due to space and resource conflicts between it and other users of the coastal zone, especially traditional fisheries.

The application and lease/license review phases attempt to address these issues, but some concerns and conflicts have continued to arise in the HRM Region and elsewhere despite these processes (Millar, 2002). In recognition of ongoing public concern, the Nova Scotia Department of Agriculture and Fisheries (NSDAF) is currently leading the implementation of an industry-wide Environmental Monitoring Program (EMP), which endeavours to address potential environmental impacts due to aquaculture operations (NSDAF, 2004). Through programs such as the EMP, understanding of the impacts of aquaculture continues to expand and evolve, but knowledge gaps remain and more research still needs to be done to provide a complete picture of the industry's effects on the environment (Strelioff, 2004).

Threats to aquaculture operations

Marine bioinvasions can have significant impacts on aquaculture operations. For example, invasive tunicates such as *Ciona intestinalis* and *Botryllus schlosserii* have become a growing concern for the shellfish industry in Nova Scotia. The green crab, *Carcinus maenas* and the green alga, *Codium fragile* ssp. *tomentosoides* are also potential threats to the shellfish industry. More information about the impacts of these invasive species on aquaculture operations is presented in the Marine Bioinvasions section of this document.

MSX is a microbial parasitic disease in oysters that has been a major problem for oyster growers and harvesters throughout the mid-eastern United States, particularly in Chesapeake Bay and Delaware Bay, since the late 1950's. MSX was unknown in Canadian populations of eastern (American) oysters, (*Crassostrea virginica*), untilOctober 2002, when it was identified as being cause of mass mortalities in the Bras d'Or Lakes (DFO 2005a). The infections pose no human health threat, but have impeded aquaculture development due to concerns about transfers from positive sites to unaffected sites (inter- and intra-provincially) and the potential for spread (2005b).

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19 - Marine transportation

The Atlantic coast of Nova Scotia is a busy marine transportation area. Two commercial ports occur in HRM: Halifax (Unit 5) and Sheet Harbour (Unit 6). Halifax is one of Canada's largest commercial ports, handling over 14 million metric tonnes of cargo in 1999 (Halifax Port Authority 2004a). It has one of the world's deepest (18 m at low tide) and largest natural harbours (Halifax Port Authority 2004b). Halifax Harbour is approached directly from the sea and has minimal currents and tides. It is always ice-free and therefore accessible year round. Halifax lies only 86 km from the Great Circle Route between Europe and North America (Government of Nova Scotia 2003) and is strategically located near major shipping lanes (Figure 19-1) (Halifax Port Authority 2004a). Thus the Port of Halifax is the first east coast inbound port and the last outbound port on the North American continent (Halifax Port Authority 2004b). For ships operating on the North Atlantic and on Round-the-World and Suez routes, the Port of Halifax enables the shortest ocean voyage.

Halifax is Nova Scotia's busiest port and a regular port of call for more than 20 direct liner services to ports around the world (Halifax Port Authority 2004a). Served by over thirty shipping lines, the Port of Halifax offers connections to more international ports than any other Canadian port (Government of Nova Scotia 2003). In 2002, international cargo accounted for 81.5% of the total cargo (Statistics Canada 2002) (Table 19-1). The total tonnage handled at the port of Halifax was 12.9 Mt in 2002 (Statistics Canada 2002) (Table 19-1 & 19-2). Halifax was the top port of loading of non-metallic minerals (other than petroleum and gasoline) in the Atlantic region in 2001 (2 662 000 t) and 2002 (2 910 000 t) (Statistics Canada 2002).

Table 19-1: Shipping at ports in HRM in 2002 (Statistics Canada 2002)

Port	Ballast			Cargo			Total tonnage handled ('000 t)
	Number of movements	Gross tonnage ('000 t)	Net tonnage ('000 t)	Number of movements	Gross tonnage ('000 t)	Net tonnage ('000 t)	
International							
Halifax	1033	29 491	15 433	1617	64 033	28 787	10 498
Sheet Harbour	15	462	215	14	421	202	250
Domestic							
Halifax	130	1690	1008	256	4168	1809	2385

Table 19-2: Domestic and international shipping – cargo tonnage loaded and unloaded at Halifax port in 2002 (Statistics Canada 2002)

Domestic			International			Domestic and International		
Loaded	Unloaded	Total handled	Loaded	Unloaded	Total handled	Loaded	Unloaded	Total handled
				'000 t				
1478	907	2385	5246	5252	10 498	6724	6159	12 883

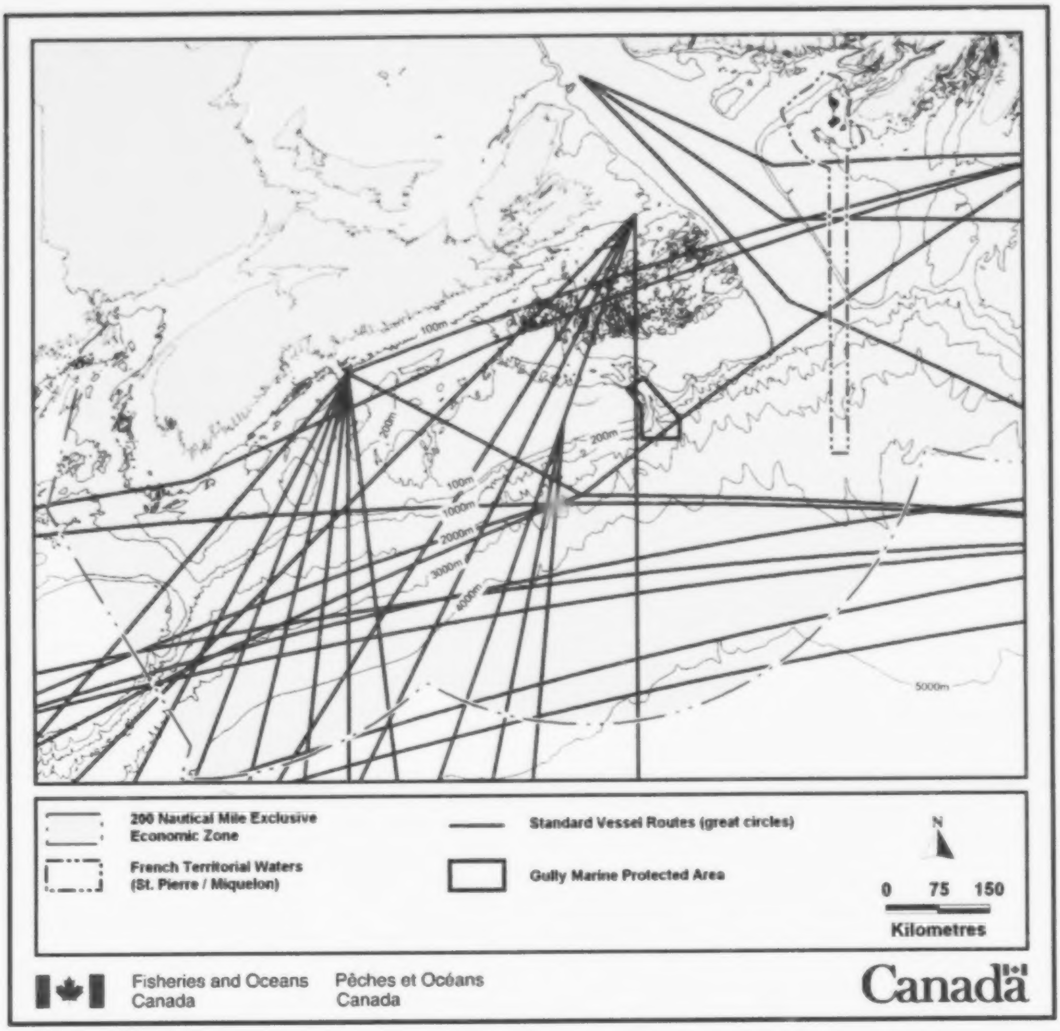
100m
200m
200m
100m
1000m
2000m
3000m
4000m
5000m
200 Nautical Mile Exclusive Economic Zone
French Territorial Waters (St. Pierre / Miquelon)
Standard Vessel Routes (great circles)
Gully Marine Protected Area
N
0 75 150
Kilometres
Fisheries and Oceans Canada
Pêches et Océans Canada
Canada

Figure 19-1: Standard shipping routes along the Atlantic coast of Nova Scotia

Completed in 1988, the Port of Sheet Harbour is Nova Scotia's newest offshore terminal and shipping facility (Eastern Shore Magazine 2004). It is conveniently located approximately 80 km west of the Great Circle Route (Government of Nova Scotia 2003) and is the closest marine facility to the Sable Island Offshore Oil Fields (Eastern Shore Magazine 2004). Its approach channel has no width restrictions and a low tide depth of 11-15 m (Government of Nova Scotia 2003). Compared to the Port of Halifax, Sheet Harbour handles less shipping (Table 19-1).

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20 - Tourism and recreation

Tourism is an important industry for Nova Scotia. More than 2.1 million people visited Nova Scotia in both 2002 and 2003 (Government of Nova Scotia 2003a, 2004). Tourism was a $1.3 billion industry for the province in 2002 (Government of Nova Scotia 2003b). The Halifax-Dartmouth area grossed the highest tourism generated revenues ($613 million) of all regions in Nova Scotia in 2002 (Government of Nova Scotia 2003b). Many sectors of the Nova Scotia economy benefit from tourism. In addition, tourism generates jobs (34 700 direct and indirect jobs in 2002) (Government of Nova Scotia 2003b).

Canadians account for 83% of all visitors to Nova Scotia, with approximately 55% of visitors coming from Atlantic Canada (Government of Nova Scotia 2003a). Ontario is the second largest market at 17% and Quebec and western Canada each represent 5% of total visitors. American visitors represent 15% of the total visitation with overseas visitation representing 3%. In addition to non-resident visitors, Nova Scotians also travel within the province, making almost six million trips annually (Government of Nova Scotia 2003b).

Tourists come to Nova Scotia for various reasons. Visiting friends and relatives accounts for the most frequent purpose (41%), followed by general pleasure and recreation (29%) (Corporate Research Associates 2001). The main reasons why pleasure travellers choose Nova Scotia is because they want to visit Atlantic Canada, and for general scenery and sightseeing (Table 20-1). July and August are the peak tourism months in the province (Government of Nova Scotia 2003a).

Table 20-1: Reasons why pleasure travellers choose Nova Scotia (Corporate Research Associates 2001)

Reason for visit	Percentage of total (%)
Wanted to visit Atlantic Canada	22
General scenery/sightseeing	17
Opportunity to visit friends/relatives	10
Never been to Nova Scotia before	10
To visit specific location/area	10
Coastal scenery	4
Recommended by others	4
Been before	3

Nova Scotia offers an array of recreational opportunities to attract tourists. Many visitors to the province participate in outdoor activities (Table 20-2).

Table 20-2: Percentage of visitors who participated in various vacation activities (Corporate Research Associates 2001)

Activity	Percentage (%)
General sightseeing	72
Leisure walking/hiking	55
Visit friends/relatives	55
Shopping (e.g., crafts, antiques)	51
Craft shops/studios	45
National/provincial historic sites	36
Nature observation	34
Beaches/exploring	31
Museums	28
National/provincial park	24
Birding	9
Beach – swimming/sunbathing	9
Wilderness hiking	7
Guided tours	7
Fishing/sightseeing boat tour	7
Golfing	6
Whale/seabird boat tour	5
Bicycling	2
Freshwater canoeing/kayaking	2
Sea kayaking	1

National historic sites

National historic sites are popular attractions for tourists and residents. Six national historic sites are located within Halifax Regional Municipality (HRM), five of which (Fort McNab, Halifax Citadel, Georges Island, the Prince of Wales Tower and York Redoubt) are part of the Halifax Defence Complex, a series of fortifications around Halifax built by the British military to defend the city (Table 20-3) (Parks Canada 2003a).

Table 20-3: National historic sites in SHACI Units 4, 5 and 6

Site	Unit	Description
Fort McNab	5	• Strategically situated at the south end of McNabs Island • Served as a gun battery and guarded the outer channels to Halifax Harbour • Was responsible for checking ships to ensure they did not pose a risk to port security • Accessible during summer by private ferry from Cable Wharf in downtown Halifax
George's Island	5	• Small drumlin located in the middle of Halifax Harbour • Was an important seaward defence for Halifax's naval base • Not presently open to the public but future visitation is expected
Halifax Citadel	5	• Excellent example of a 19th-century bastion fortification complete with defensive ditch, ramparts, musketry gallery, powder magazine and signal masts • Commemorated as nationally significant in Canada's development and evolution from colony to nation • Features guided tours, an audio-visual presentation and modern exhibits • Visitation in 2003 was 164 000
Prince of Wales Tower	5	• Built in 1796-97 to protect British batteries from French attack • Located in Point Pleasant Park • The first tower of its type in North America • Exhibits depict the tower's history, architectural features and significance as a defensive structure.
Sambro Island Lighthouse	4	• Established in 1758, it is the oldest operational lighthouse in North America • Located on a granite island roughly 2 nm outside the entrance to Halifax Harbour
York Redoubt	5	• Established in 1793 • Situated on a high bluff overlooking the entrance of Halifax Harbour

Complied from Government of Nova Scotia 2003c; Parks Canada 2003b, 2003c, 2003d, 2003e, 2003f; and NSLPS No date

Provincial, community and heritage parks

Halifax Regional Municipality has a variety of provincial, community and heritage parks that offer a range of recreational activities (Table 20-4).

Table 20-4: Provincial, community and heritage parks with coastal components in Units 4, 5 and 6 (compiled from HRM 2004, NSDTCH 2004)

Name	Unit	Swimming	Hiking	Kayaking	Picnic facilities	Boardwalk	Fishing
Clam Harbour Beach Provincial Park	5		X	X	X		
Cole Harbour - Lawrencetown Coastal Heritage Park System	5		X				
Lawrencetown Beach Provincial Park	5	X				X	
Marie Joseph Provincial Park	6				X		
Martinique Beach Provincial Park	5	X			X	X	
McCormack's Beach Provincial Park	5				X	X	X
McNabs Island Provincial Park Reserve	5		X		X		
Point Pleasant Park	5		X		X		
Rainbow Haven Beach Provincial Park	5	X				X	
Shubie Park	5		X				
Sir Sanford Fleming Park	5	X					
Spry Bay Provincial Park	6						
Taylor Head Provincial Park	6	X	X	X	X	X	
Crystal Crescent Beach Provincial Park	4	X	X			X	
Bishop Park (Hubbards Cove)	4		X		X		
Cleveland Beach Provincial Park	4	X			X		
Hubbards Provincial Park[1]	4						
William E. Degarthe Provincial Park[2]	4						
Queensland Beach Provincial Park	4	X					

[1] Has wharf and boat launch

[2] This park, located in and around Peggy's Cove, offers spectacular views of plunging breakers close to shore.

Beaches

Halifax Regional Municipality has a number of good swimming locations located in Provincial Parks as well as many other beaches along the coast of Units 4-6 (Table 20-5).

Table 20-5: Provincial Park Beaches in SHACI Units 4, 5 and 6 (compiled from NSDNR 2004, NSDTCH 2004)

Beach	Unit
Bayswater Beach	4
Hubbards Beach	4
Queensland Beach	4
Cleveland Beach	4
Crystal Crescent Beach	4
McCormacks Beach	5
Rainbow Haven Beach	5
Conrods Head Beach	5
Lawrencetown Beach	5
Martinique Beach	5
Clam Harbour Beach	5
Taylor Head Bay Beach	6

Boat tours and charters

Boat tours and charters are popular tourist attractions, and are available for a variety of coastal recreational purposes, including whale watching, diving and kayaking (Table 20-6).

Whale watching

Nova Scotia is one of the finest and most popular locations for whale watching on the eastern seaboard. Within HRM, St. Margarets Bay and its surrounding waters (Unit 4) and the approaches to Halifax Harbour (Unit 5) are prominent whale watching areas. These areas are regularly visited by harbour porpoises, white-sided dolphins, white-beaked dolphins, fin whales and minke whales (Conway pers. comm. 2003, Gowans pers. comm. 2003). Occasional sightings of blue, humpback and North Atlantic right whales may also occur. Various whale watching tours are available (Table 20-6).

Diving

Diving is a popular sport for residents and tourists. Roughly 3 000 shipwrecks have occurred along Nova Scotia`s shores over the centuries, providing excellent opportunities for divers (NSDTCH 2004). Diving charters in Units 4, 5 and 6 are identified in Table 20-6.

Table 20-6: Boat charters and tours in Units 4, 5 and 6

Organization	Unit	Bird watching	Sailing charters & cruises	Whale watching	Diving	Sports fishing	Ferry to McNab's Island	Cycling	Coastal hiking tours	Kayaking	Dates of operation
A & M Sea Charters	5	X		X		X	X				All year
Blue Shark Fishing Charters	5	X	X	X		X					Jun 1-Oct 30
Happy Dude's Surf Emporium[1]	5									X	
McNab's Island Ferry & Nature Tours	5	X						X	X		All year
Murphy's Scenic Boat Tours	5	X				X					May 15-Oct 15
Some Sites 2 Sea Eco Tours & Charters	5	X	X	X	X	X	X		X		All year
TaxSea on the Harbour	5	X	X	X		X					Apr 15-Oct 15
Adventures East	5								X	X	
Captain Ed's Charters	5	X	X	X	X	X	X				May 1-Dec 31
Canadian Sailing Expeditions	5	X		X	X			X	X	X	June -October
Divequest	5				X						All year
Divers World	5		X		X						All year
Four Winds Charters[2]	5	X		X	X	X	X	X	X		May 1-Oct 31
Harbour Hopper	5										May 1-Oct 30
Into the Wilderness	5		X	X						X	All year
Lobstermen Tours	5	X				X[3]					June-Sept
Murphy's on the Water	5	X	X	X		X				X	May 1-Oct 31
New Dawn Charters	5	X		X		X					May 1-Nov 30
Peggy's Cove Express	5			X							Jun 15-Sep 30
Purcell's Cove Marine	5	X		X	X	X					All year
SeaSun Kayak School & Adventures	4									X	Apr 1-Oct 31
Skipper Dave's Charters	4		X	X	X	X					Apr 1-Nov 30
Shining Waters Marine	4		X								
Tall Ship Silva	5	X		X	X						May 15-Oct 30
Thrumcap Sailing Charters	5	X	X	X	X						May 1-Oct 31
Torpedo Rays Scuba Adventures	5				X						All year
Water Taxi	5						X				Jun 1-Sep 30
Peggy's Cove Water Tours	4	X		X		X					Jun 1-Oct 1

[1] Also provides zodiac tours

[2] Also provides ferry to George's Island

[3] Lobster fishing on a traditional working lobster boat

Compiled from NSDTCH 2004, Adventure Nova Scotia (2005)

Sailing

With its varied coastline, featuring small coves, inlets, and harbours, the waters around Nova Scotia provide some of the finest sailing venues in North America. Several sailing charters and cruises are available in HRM (Table 20-6). In addition, various marinas and yacht clubs provide shelter and supplies (Table 20-7).

Some of the more extensively used waterbodies for sailing include St. Margarets Bay, French Village Harbour, Hubbards Cove, Cub Basin, Rogues Roost, Halifax Harbour, Bedford Basin, Northwest Arm and along the Eastern shore in Owls Head Bay (Pietrzak pers. comm. 2005).

Table 20-7: Marinas and yacht clubs in Units 4, 5 and 6 (NSDTCH 2004)

Name	Location	Unit
Hubbards Yacht Club	Hubbards	4
St. Margarets Sailing Club	St. Margarets Bay	4
Shining Waters Marine	Head St. Margarets Bay	4
Armdale Yacht Club	Armdale	5
Bedford Basin Yacht Club	Bedford	5
Dartmouth Yacht Club	Bedford Basin	5
Queen's Wharf Marina	Halifax	5
Royal Nova Scotia Yacht Squadron	Northwest Arm	5
Shearwater Yacht Club	Shearwater	5
Petpeswick Yacht Club	Musquodoboit Harbour	5

Several small craft harbours in SHACI Units 4-6 have been designated to accommodate commercial fisheries vessels and recreational vessels, and are managed by various Harbour Authorities. These harbours are located at (DFO 2003):

- Blandford (Shoal Cove) (Unit 4)
- Northwest Cove (Unit 4)
- Mill Cove (Unit 4)
- Fox Point (Unit 4)
- Boutliers Point (Unit 4)
- Peggys Cove (Unit 4)
- Shad Bay (Unit 4)
- Shag Harbour (Prospect Point) (Unit 4)
- Lower Prospect (Unit 4)
- Terence Bay (Unit 4)
- Sambro (Unit 4)
- Eastern Passage (Unit 5)
- East Chezzetcook (Unit 5)
- Three Fathom Harbour (Unit 5)
- Little Harbour (Unit 6)
- Owls Head (Unit 6)
- Carters Point (Murphy Cove) (Unit 6)
- Coopers Point (Unit 6)
- Marie Joseph (Unit 6)

In addition to the small craft harbour in SHACI units 4-6, there are 23 boat ramp locations. These provide locations for companies, individuals and other agencies with a suitable ramp for launching commercial or recreational boats. The Nova Scotia Department of Agriculture and Fisheries maintains the current Nova Scotia Ramp Report on their website. The site provides a comprehensive report on location, maps, photographs and description of conditions of the ramps by county throughout the province. These are located at (NSDAF 2005):

• Hubbards Yacht Club (Unit 4)	• Eastern Passage - Langilles Boating Centre (Unit 5)
• Hubbards (Unit 4)	• Eastern Passage - Fisherman's Cove (Unit 5)
• Boutlier's Point (Unit 4)	• Porter's Lake Park (Unit 5)
• Terrence Bay River (Unit 4)	• Porter's Lake - Keizer's Drive (Unit 5)
• Halifax - Fleming Road (Unit 5)	• Dollar Lake (Unit 5)
• Halifax - Jubilee Road (Unit 5)	• East Chezetcook (Unit 5)
• Halifax - Seaview Park (Unit 5)	• Head of Jeddore - Salmon River (Unit 5)
• Bedford Basin Basin - Lionhead Pk.(Unit 5)	• Oyster Pond (Unit 5)
• Lake Micmac - Red Bridge Pond (Unit 5)	• Lower Ship Harbour (Unit 6)
• Dartmouth - Alderney Street (Unit 5)	• East River Sheet Harbour (Unit 6)
• Birches Park - Portland Estates (Unit 5)	• Lochaber Mines (Unit 6)
• Oakfield Park - Waverley (Unit 5)	

Sport fishing

Charters are available for deep sea fishing (Table 20-6) and often provide special licenses for shark and tuna fishing. In addition to deep sea fishing, recreational fishing and angling are permitted in various lakes around the province, provided the appropriate fishing license is purchased and specific regulations are followed. Sport fishing events such as shark, trout, bass and pickerel derbies and tournaments are frequent events in the province (NSDAF 2001).

Birding

Nova Scotia offers unique bird watching experiences and boasts a wide variety of seabirds, shorebirds and waterfowl along its Atlantic coast. Water-based birding is provided by many charters and boat tours in Units 4, 5 and 6 (Table 20-6). For more information about the various bird species and their locations in Units 4, 5 and 6, refer to the Marine Birds section of this document.

Sea kayaking

Sea kayaking has grown over the last few decades in eastern Canada. It now attracts tourists to Nova Scotia and provides summertime jobs in the province. In some areas, such as Halifax Harbour (Unit 5), sea kayaks are a common summertime site (Cunningham 2000). Several kayaking charters are available in HRM (Table 20-6). Some popular sea kayaking routes in Units 4, 5 and 6 are given in Table 20-8.

The increasing number of sea kayaks in recent years has led to some conflict with other users of coastal areas (Cunningham 2000). To address this issue, a coastal water trail between Lunenburg and Halifax was identified. Recreational boaters will find the Nova Scotia Coastal Water Trail a useful resource (Browne et al. 2000). This guide provides information about access for recreational boaters from Lunenburg to Halifax by identifying locations where launches and take-outs can be done without trespassing on private property (Browne et al. 2000). In addition, the guide identifies areas of attraction, accommodation, services and constraints. In HRM, the water trail flows through all of Unit 4 to Hartlen Point, Halifax Harbour (Unit 5).

Table 20-8: Sea kayaking routes in Units 4, 5 and 6 (Cunningham 2000)

Location	Unit	Points of Interest
Lower Prospect	4	Back Bay, Narrow Passage, Rogues Roost, Hearn Island, Hopson and Duck Islets, Sandy Cove, Marrs Island
Halifax Harbour	5	Department of National Defence, Historic Properties, Georges Island, the ocean terminals, Point Pleasant Park, Northwest Arm, McNabs Island, Maugher Beach, ruins of Fort McNab and Ives Point Battery, Lawlor Island, Devils Island, Fisherman's Cove, oil refineries, Canadian Coast Guard station
Porters Lake to Chezzetcook	5	Sandy Point, Porters Lake Provincial Park, Rocky Run, Lawrencetown Bach Provincial Park, Shut-in Island, Three Fathom Harbour, Wedge Island, Drumlin Headlands, Fisherman's Beach, Chezzetcook Inlet, West Chezzetcook
Little Harbour	5/6	Cut Leg Island, Bald Island, Laney Island, Seal Rocks, Sand Bar, Long Cove, Cuckold Island, Owls Head, Heron Point, Cable Island, Clam Harbour, Harbour Point, Porters Island, Long Island, Egg Island, Clam Harbour Beach
Murphy Cove	6	Ship Rock, Wolfes Point, Long Creek, Harbour Island, Sandy Cove, Friar Island, Monahan Island, Outer Island, Middle Island, Tuckers Head, Long Island, Borgles Island
Tangier Harbour	6	Hog Island, Jeans Field Point, Inner Baltee, Outer Baltee, Baltee Head, Western Cove, Tangier Shoal, Tangier Island, Outer Island, Sandy Cove, glacial striations in cliffs, Carryover Cove, Abriels Fish Plant
Popes Harbour	6	Gerard Island, Harbour Island, Gerard Head, Glawsons Point, The Bawleen, Goose Marsh, Cap Island, Gerard Island (east), The Portage, Popes Head, Stoney Island, Popes Shoals
Mushaboom Harbour	6	Taylors Head Beach, Taylors Head, Psyche Rock, Pyches Island, Little Guilford Islands, Guilford Passage, Sheet Rock, Salisbury Island, Leslie Island, Western Isles
Sober Island	6	Sheet Harbour, Sheet Harbour Passage, Sober Island Pond, sheet Rock, The Flats, Fishery Island, Hardwood Island Reef, Hardwood Island, Sand Point, Hydroponic greenhouses, Campbell Island, Speck Island
Bay of Islands (Port Dufferin)	6	Harwood Island, the Pancake, Sutherland Island, Speck Island, Pumpkin Island, Brother Islands, Beaver Island, Big Harbour Island, Quoddy Head
Bay of Islands (East Quoddy)	6	Flag Island, High Island, Quoddy Head, Long Island, Bird Islands, Goose Island, Black Duck Island, Brokenback Island, Baptiste Island
Ecum Secum	6	The White Islands, Little Whit Island, Frenchmans Cove, Crooks Island, Goose Gutter, Barren Island, Turners Island, Hapes Point

Coastal walking/hiking trails

Nova Scotia boasts many walking/hiking trails with varying characteristics, from mountains to deep ravines to meandering rivers to coastlines. Some of the better-known trails in SHACI Units 4, 5 and 6 are listed in Table 20-9. In Halifax, tourists can stroll the world's longest harbourfront boardwalk from Pier 21, the dockside cruise ship terminal, to Casino Nova Scotia in downtown Halifax . Along the boardwalk, visitors can explore the restored waterfront area of Historic Properties where privateers once gathered.

Table 20-9: Coastal walking and hiking trails in Units 4, 5 and 6 (compiled from Haynes 2000 and 2002, Government of N.S. 2005)

Name	Unit	Uses
Cleveland Beach Provincila Park	4	Walking, hiking
Peggy's Cove	4	Walking,hiking
Polly Cove Trail	4	Hiking
Pennant Point Trail	4	Hiking
Crystal Crescent Beach Provincial Park	4	Hiking, walking
Duncan's Cove		Hiking
York Redoubt National Historic Site	5	Hiking, biking, running
Fleming Park Trail System - Northwest Arm	5	Walking
Fleming Park Trail System - Flemming Path	5	Walking,biking, x-country skiing
Fleming Park Trail System - Seawall Walk	5	Walking, biking x-country skiing
Point Pleasant Park	5	Hiking, biking, running, wheelchair
McNabs Island	5	Hiking, biking, x-country skiing
Halifax Harbour Boardwalk	5	Walking, wheelchair
Seaview Park	5	Walking, x-country skiing
Atlantic View Trail	5	Walking, mountain biking, x-country skiing, wheelchair (part)
Salt Marsh Trail	5	Walking, hiking, mountain biking, hiking, x-country skiing
Clam Harbour Beach Provincial Park	5	Walking, hiking, wheelchair
Lawrencetown Beach Provincial Park	5	Hiking, running
Martinique Beach Provincial Park	5	Hiking, running
McCormacks Beach	5	Hiking, running, wheelchair use
Rainbow Haven Provincial Park	5	Hiking
Taylor Head Provincial Park	6	Hiking

Bouldering

In recent years, rock climbing has become increasingly popular in coastal areas of the HRM region. Bouldering, which involves climbing large erratics without the use of ropes but with crash mats underneath the climber, is particularly popular in this area. The rugged granite outcrops of the Chebucto Peninsula are particularly attractive to climbers. Some of the best known climbing routes are found around Terence Bay, while the many erratics in the Peggy's Cove area and on nearby coastal islands have attracted national attention as bouldering destinations. There are also a number of established climbing routes around Musqodoboit Harbour and Porter's Lake (see Cassidy, 2002, for details of specific routes).

The growing number of climbers using coastal areas have been cause for some environmental concern from coastal residents and organizations. Many erratics are found in sensitive coastal barrens, and the large number of people accessing these areas may cause damage to vegetation. The insertion of bolts and removal of lichen from climbing routes may also cause ecological and aesthetic degradation. Many local climbing groups are aware of these issues and encourage their members to adhere to low impact practices (e.g., Halifax Bouldering, 2005).

Cruise ships

The port of Halifax has witnessed an increased number of cruise ships in recent years, with more than 100 ships coming to the city annually, bringing tourists from all over the world (Province of Nova Scotia 2004). Halifax is conveniently located only one day's sail from New York and Boston. The port is also popular with European cruise lines because of its strategic location on the Great Circle Route. In 2003, 104 cruise ships with more than 170 000 passengers visited the port (Halifax Port Authority 2004).

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Restricted use areas

21 - Restricted land use - existing land use designations

Several coastal areas located within Units 4-6 fall under some category of restricted land use (Figures 21-1a to 21-1g). These areas are set aside for a variety of reasons including recreational use, education and enjoyment, wildlife protection, conservation and the protection of important natural and cultural places. Varying types and levels of use are permitted on different land designations but by no means should all these areas be considered protected from human activities or other potential threats. Restricted land use areas found within Units 4-6 are identified and described in this section.

Types of restricted land use areas

The many different categories of restricted land use areas found within SHACI Units 4-6 are designated by various levels of government or by private organizations, and have different uses and levels of protection. This section presents the different restricted areas (Table 21-1) and briefly describes the locations.

Community parks

This designation refers to parks operated by regional or municipal governments, as well as those operated by local community organizations, irrespective of ownership.

SS Atlantic Heritage Park
The SS Atlantic Heritage Park is located near the mass burial ground and historic monument to the victims of the SS Atlantic Wreck in Terence Bay (Unit 4). Run completely by local volunteers, it features a rock seawall and coastal boardwalk with memorial benches and a gazebo. An Interpretive Centre built on the grounds of St. Paul's Church provides numerous exhibits, including photographs, display items and original artifacts from the wreck, as well as a rest area, refreshments and washrooms. The entire site is wheelchair accessible and is open seasonally between May and October (SS Atlantic Heritage Park Society 2003).

Kidston Lake/ Rockingstone Park
This park is located on the edge of the Granite Barrens southwest of the Halifax peninsula (bordering on Units 4 and 5). "It is famous for a 40-ton erratic (large boulder) deposited in its present unstable condition when the glaciers melted about 12 000 years ago. Smaller granite boulders dot the landscape and the bedrock shows different stages of granite formation, with larger and smaller crystals indicating faster and slower cooling. The network of trails to the rock take visitors through mixed woods and patches of blueberry bushes" (HRM 2003a). The province also recognizes the Kidston Lake area as a Site of Ecological Significance for its granite barrens, the rare Greenland sandwort, and its near-urban potential (MacKinnon pers. comm. 2003).

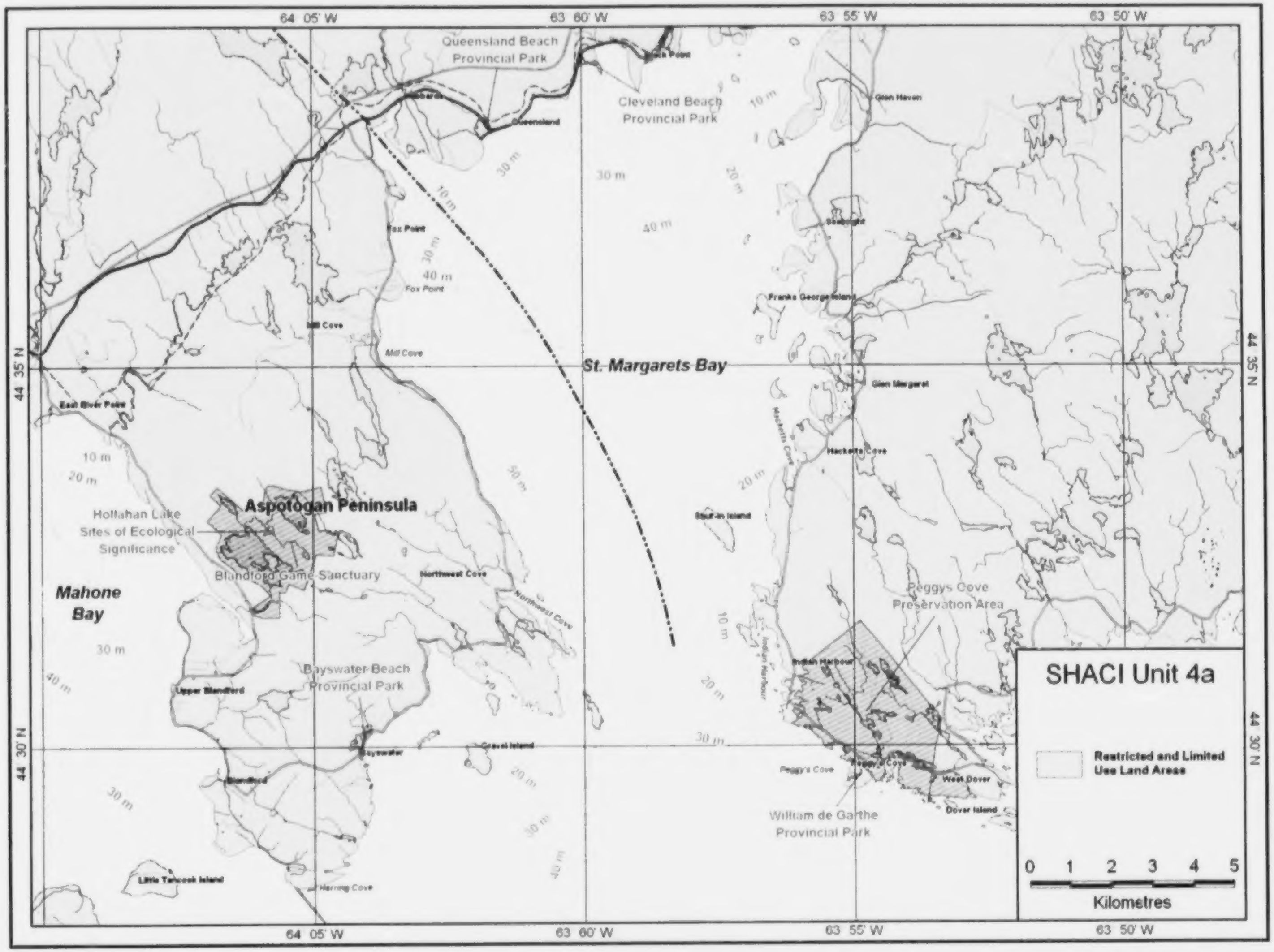


Figure 21-1a: Restricted and limited use land areas in SHACI Unit 4a (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

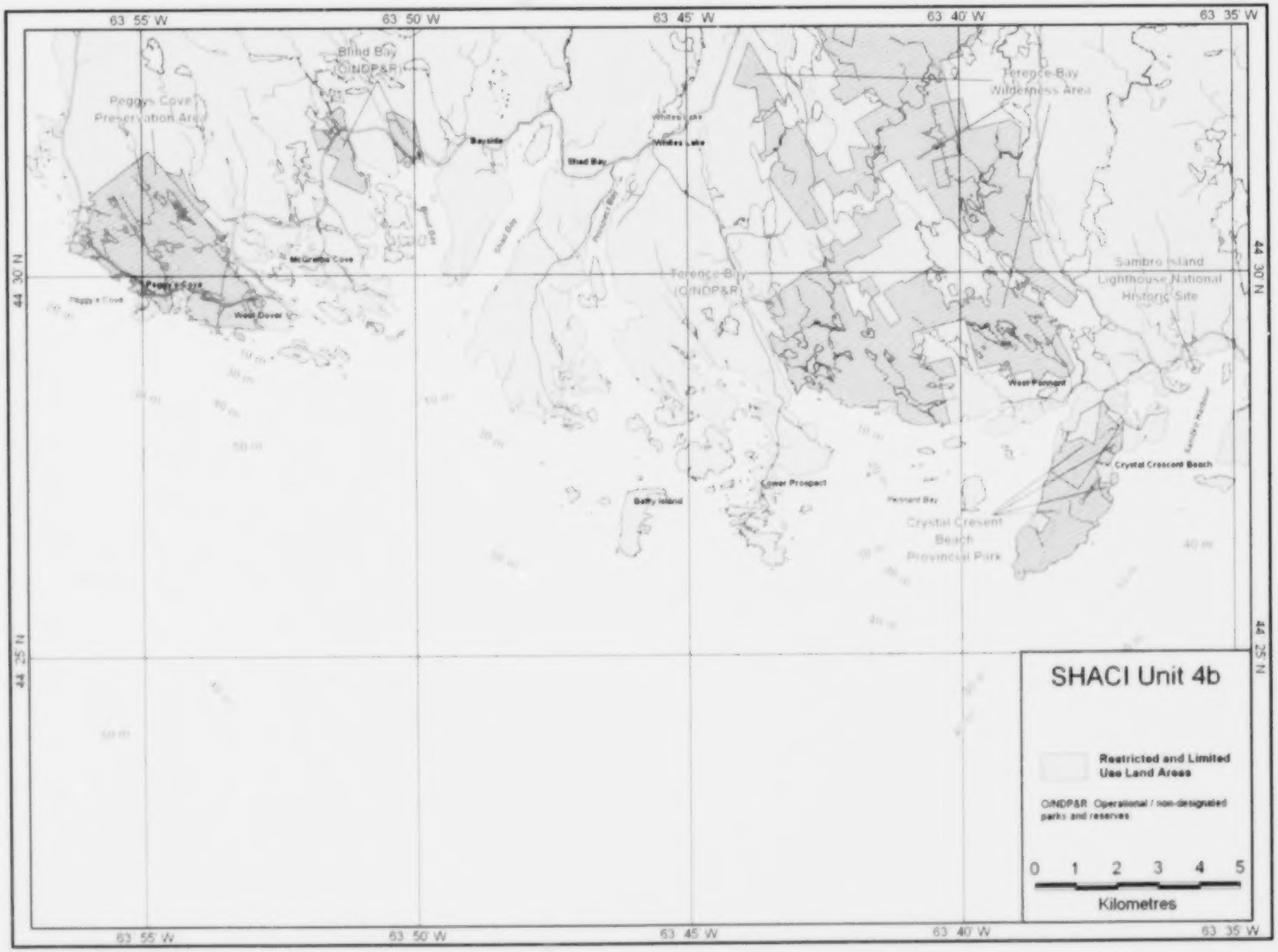


Figure 21-1b: Restricted and limited use land areas in SHACI Unit 4b (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

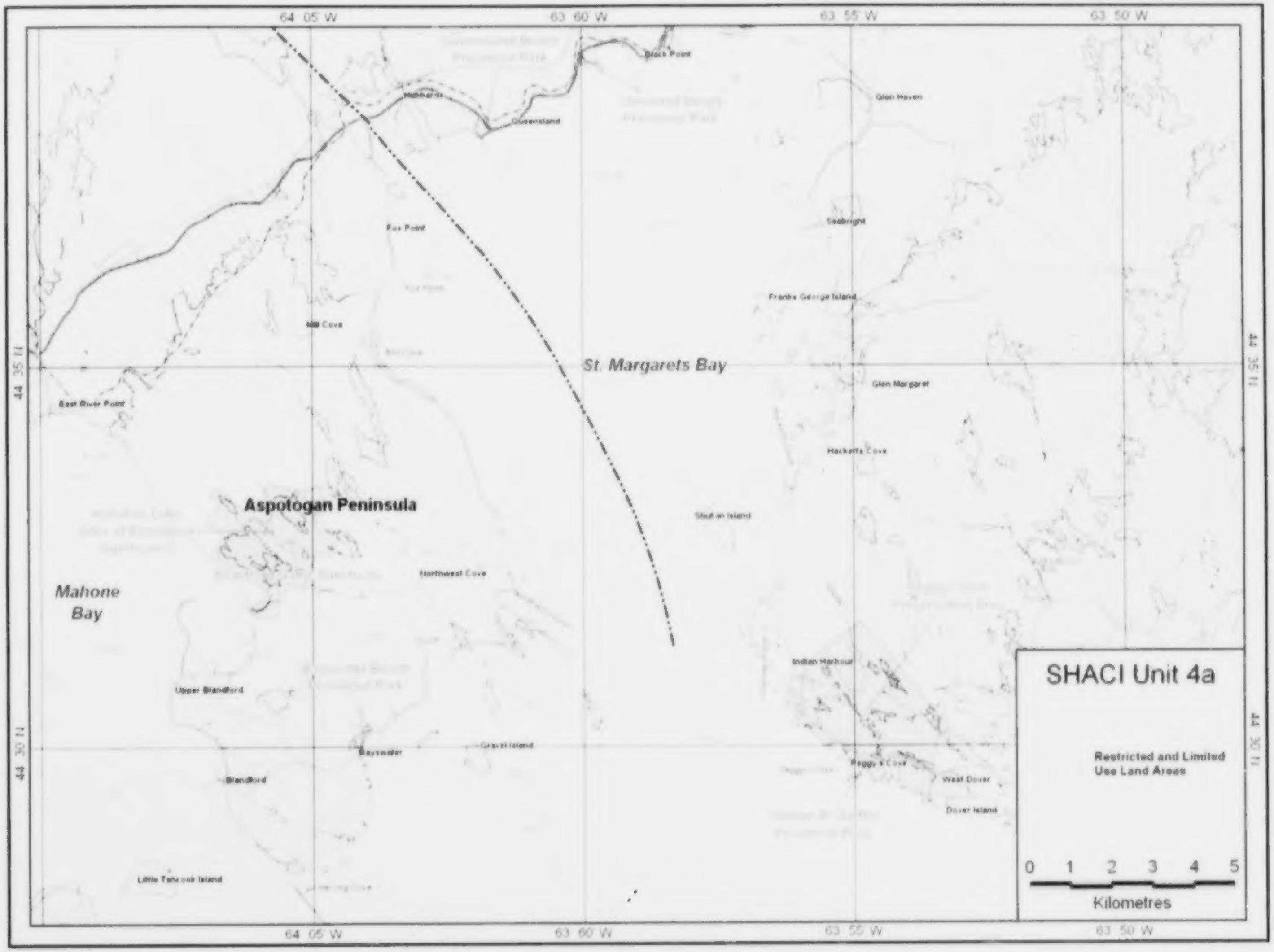


Figure 21-1a: Restricted and limited use land areas in SHACI Unit 4a (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

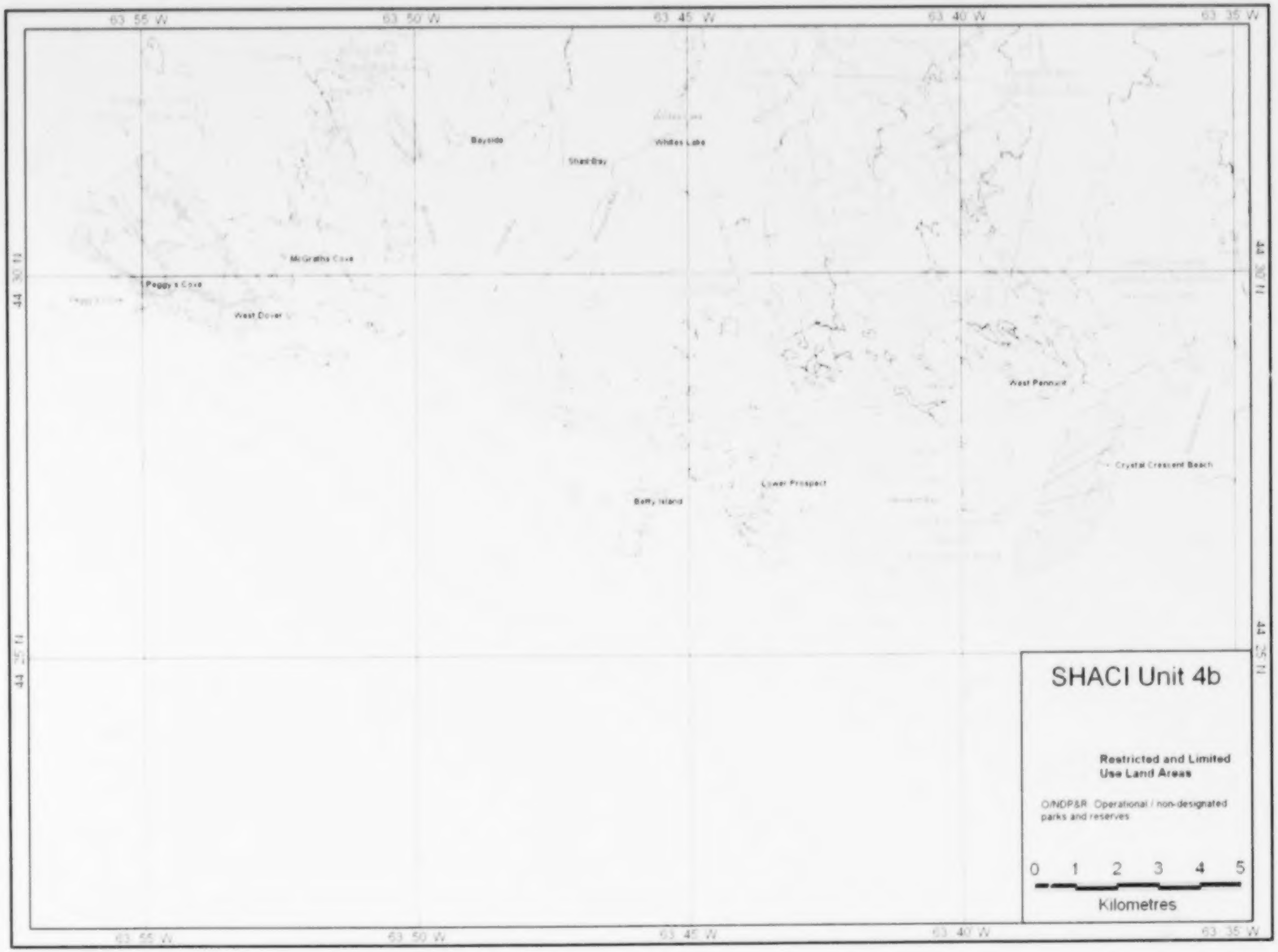


Figure 21-1b: Restricted and limited use land areas in SHACI Unit 4b (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

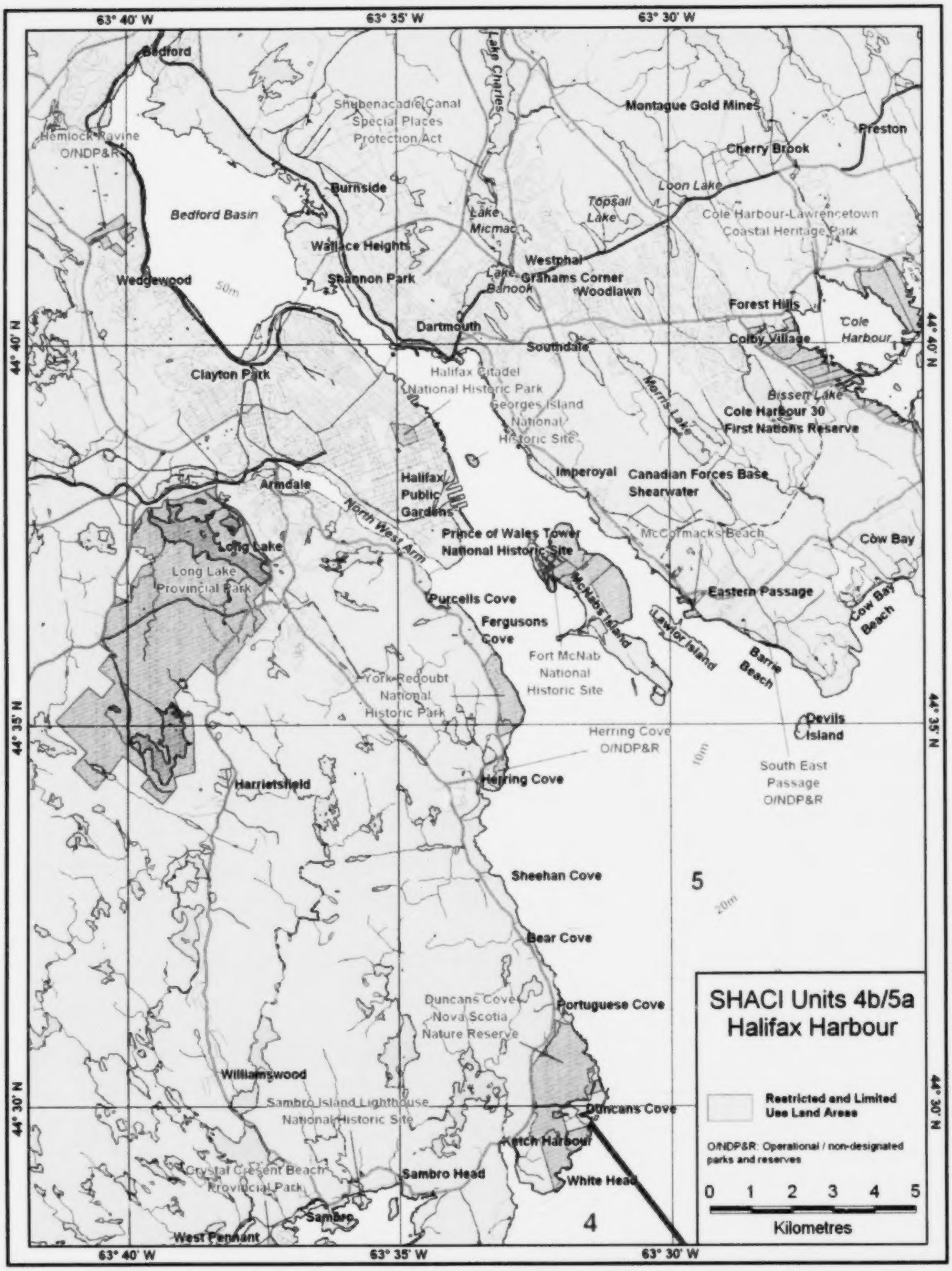


Figure 21-1c: Restricted and limited use land areas in SHACI Units 4b/5a (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

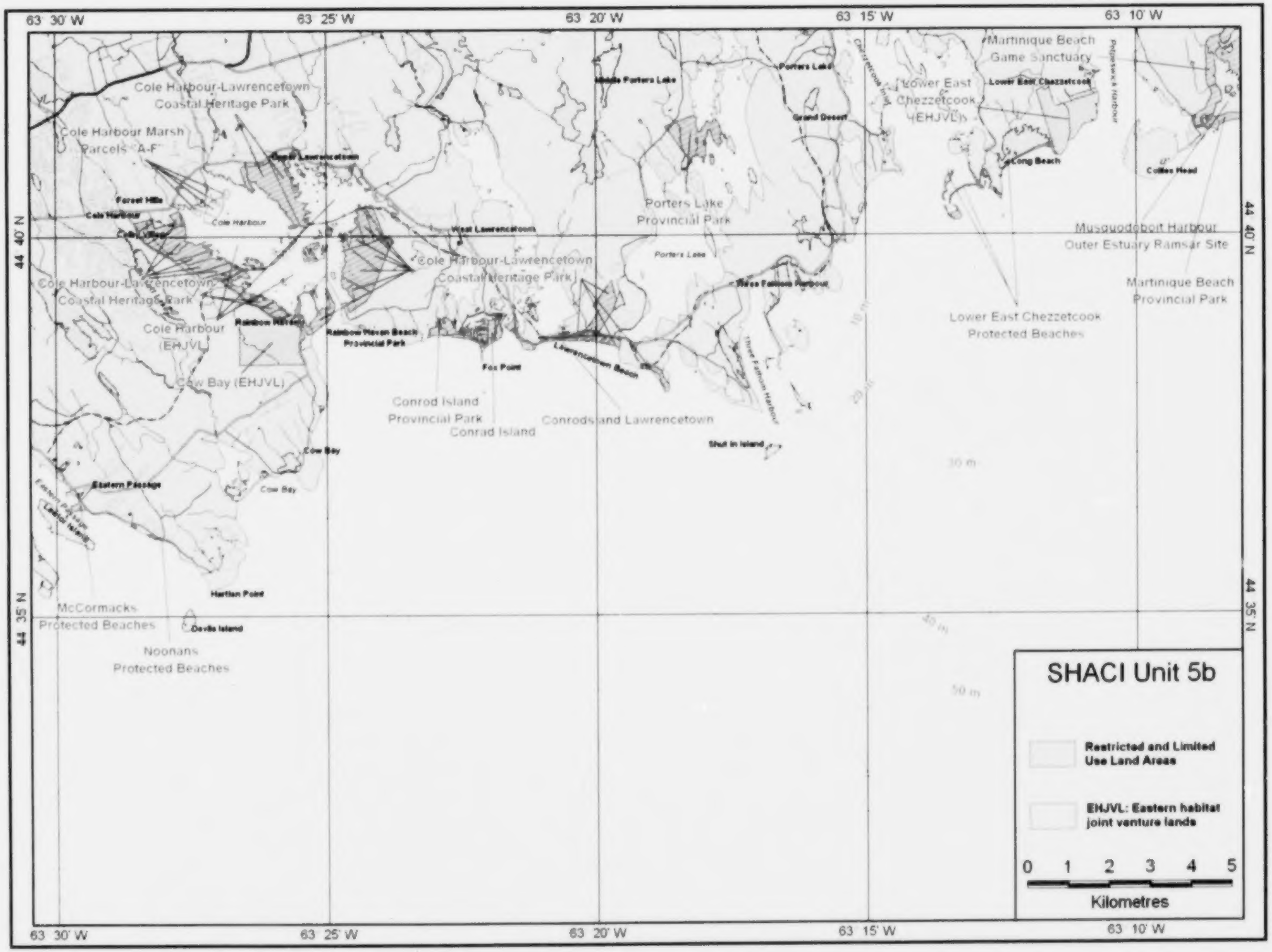

63 30' W
63 25' W
63 20' W
63 15' W
63 10' W
44 40' N
44 35' N
Cole Harbour-Lawrencetown Coastal Heritage Park
Cole Harbour Marsh Parcels "A-F"
Upper Lawrencetown
Forest Hills
Cole Harbour
Colby Village
Cole Harbour
West Lawrencetown
Cole Harbour-Lawrencetown Coastal Heritage Park
Cole Harbour-Lawrencetown Coastal Heritage Park
Cole Harbour (EHJVL)
Rainbow Haven
Rainbow Haven Beach Provincial Park
Cow Bay (EHJVL)
Fox Point
Lawrencetown Beach
Conrod Island Provincial Park
Conrad Island
Conrods Island Lawrencetown
Cow Bay
Cow Bay
Eastern Passage
Eastern Passage
Lawlor Island
Hartlen Point
Devils Island
McCormacks Protected Beaches
Noonans Protected Beaches
Middle Porters Lake
Porters Lake
Grand Desert
Porters Lake Provincial Park
Porters Lake
Three Fathom Harbour
Three Fathom Harbour
Shut In Island
Chezzetcook Inlet
Lower East Chezzetcook (EHJVL)
Martinique Beach Game Sanctuary
Lower East Chezzetcook
Petpeswick Harbour
Long Beach
Lower East Chezzetcook Protected Beaches
Musquodoboit Harbour Outer Estuary Ramsar Site
Martinique Beach Provincial Park
Collins Head
10 m
20 m
30 m
40 m
50 m
SHACI Unit 5b
Restricted and Limited Use Land Areas
EHJVL: Eastern habitat joint venture lands
0 1 2 3 4 5
Kilometres

Figure 21-1d: Restricted and limited use land areas in SHACI Unit 5b (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

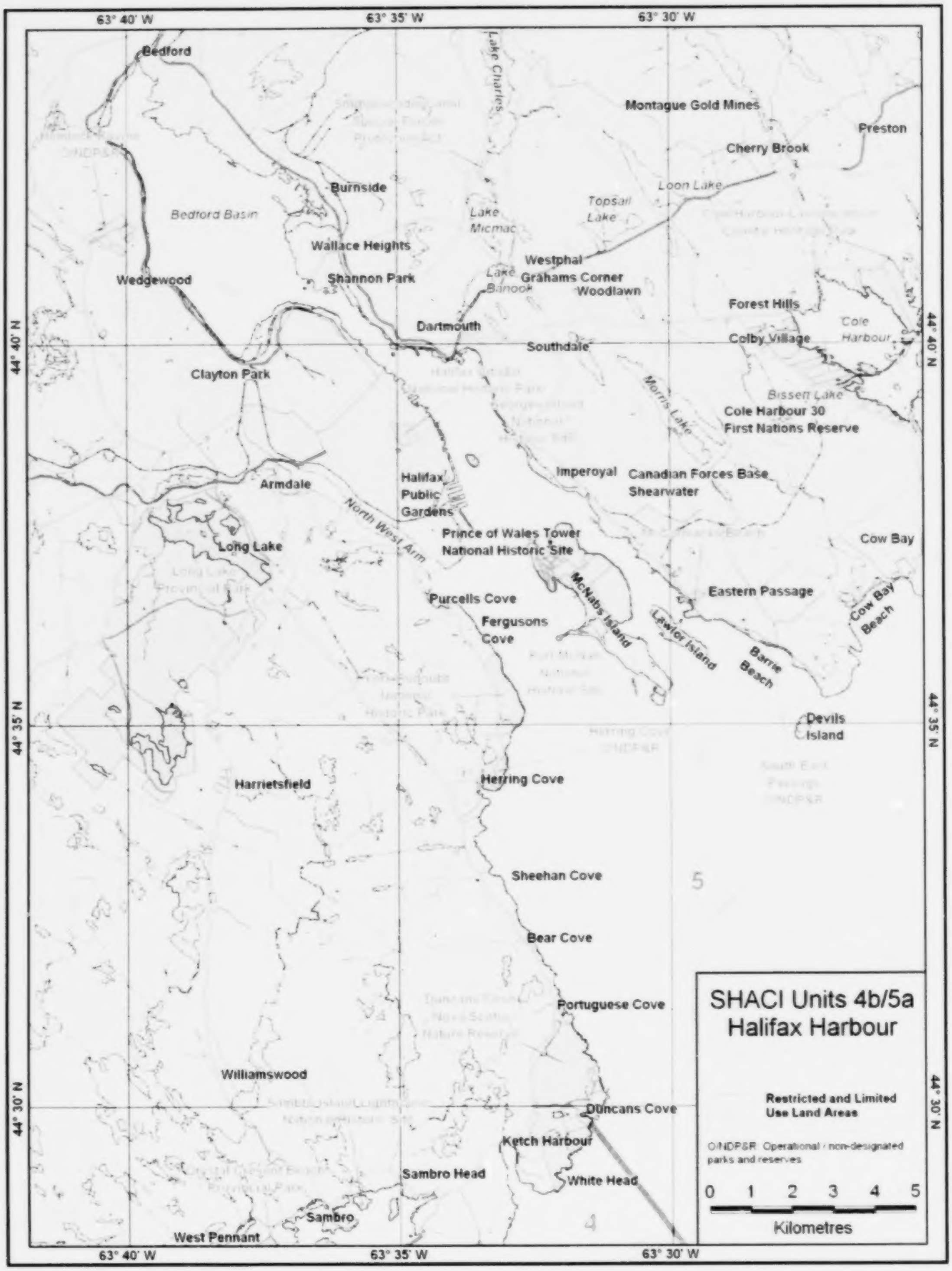


Figure 21-1c: Restricted and limited use land areas in SHACI Units 4b/5a (based on data from CCIBPCTCS 1974. NSMNH 1991. Burnett and Hundert 1994. NSDNR 2002a and Province of Nova Scotia 2003a.b). Basemap layers (NRCan).

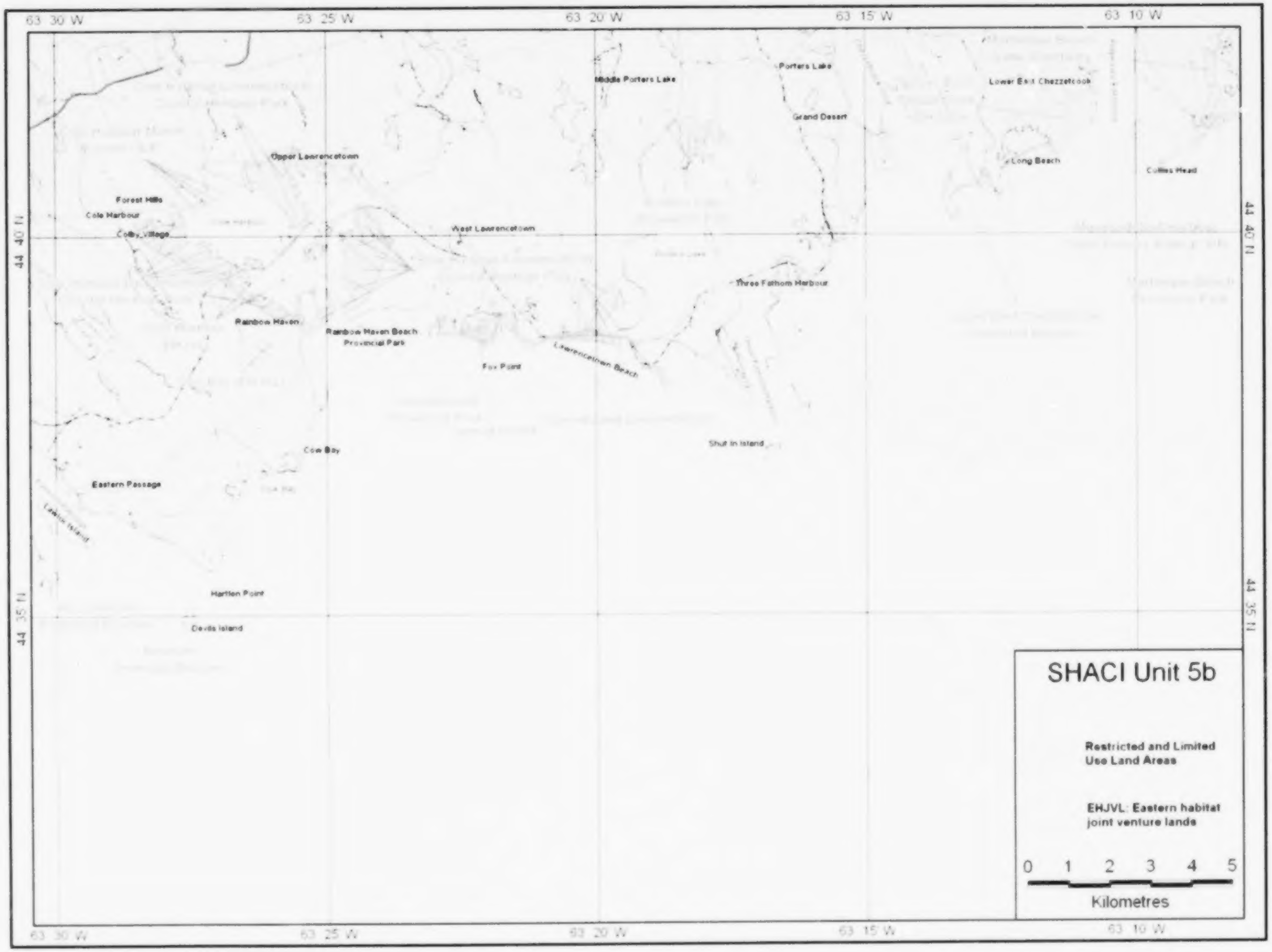


Figure 21-1d: Restricted and limited use land areas in SHACI Unit 5b (based on data from CCIBPCTCS 1974. NSMNH 1991. Burnett and Hundert 1994. NSDNR 2002a and Province of Nova Scotia 2003a.b). Basemap layers (NRCan).

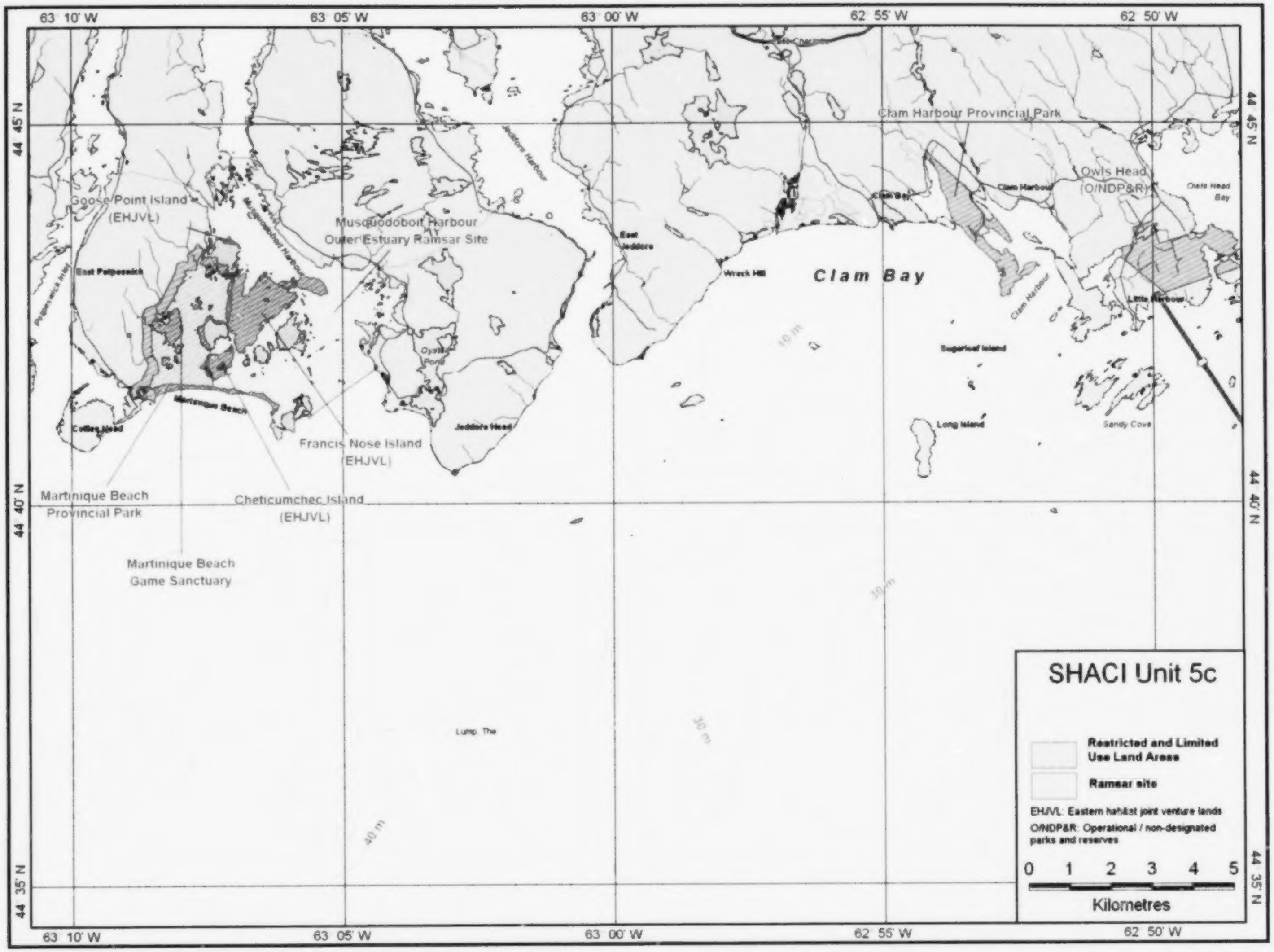


Figure 21-1e: Restricted and limited use land areas in SHACI Unit 5c (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

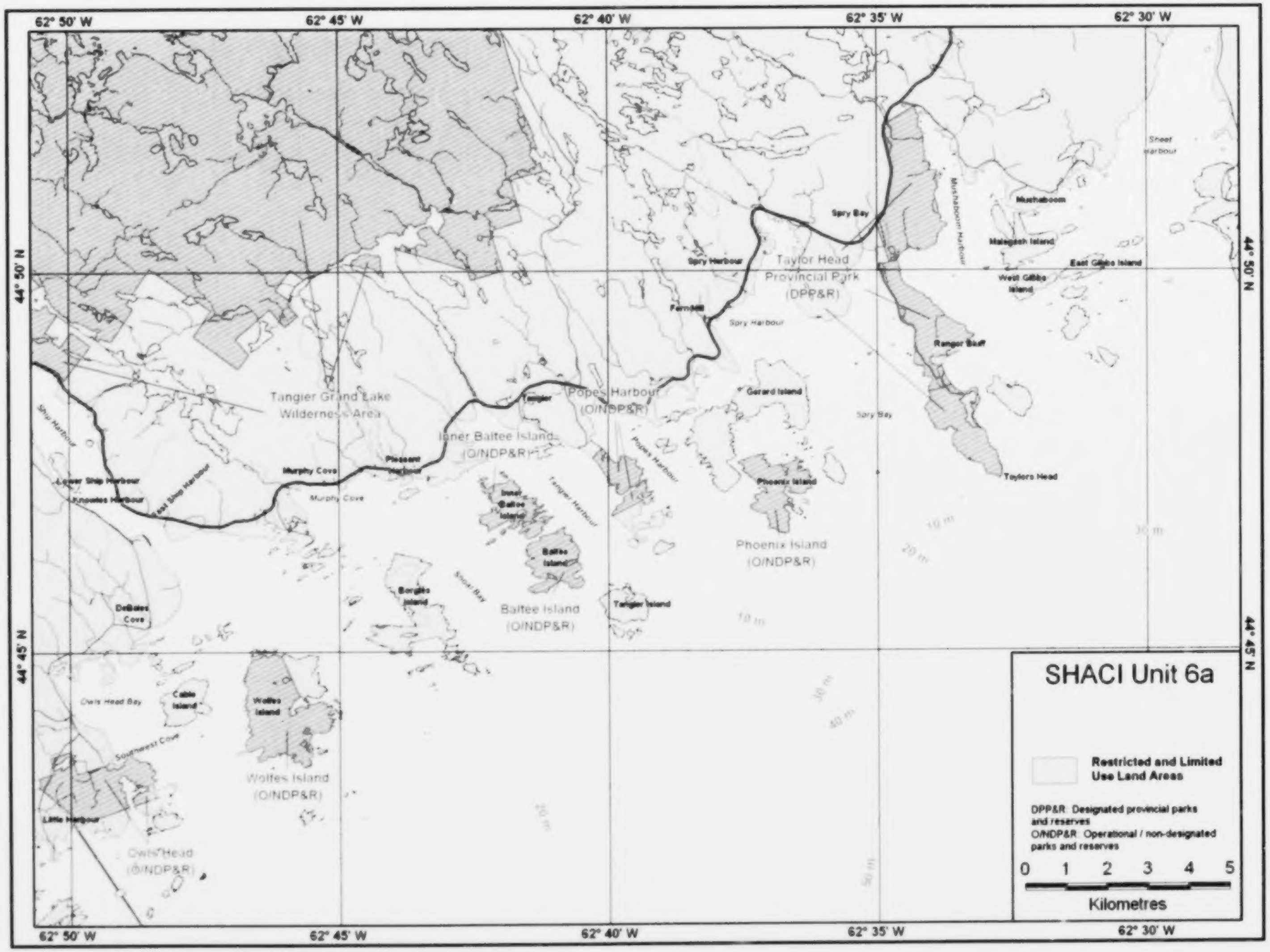


Figure 21-1f: Restricted and limited use land areas in SHACI Unit 6a (based on data from CCIBPCTCS 1974. NSMNH 1991. Burnett and Hundert 1994. NSDNR 2002a and Province of Nova Scotia 2003a.b). Basemap layers (NRCan).

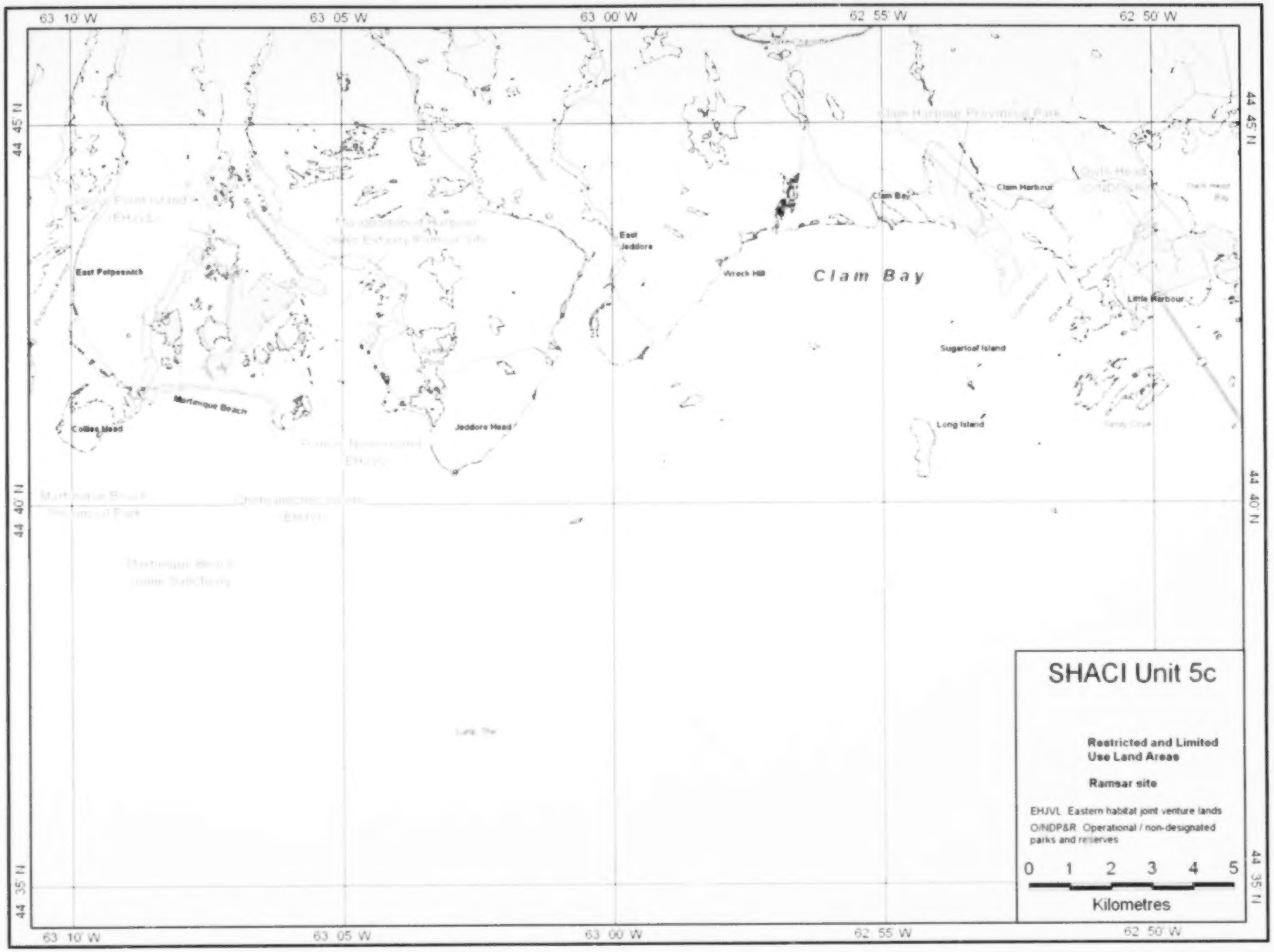


Figure 21-1e: Restricted and limited use land areas in SHACI Unit 5c (based on data from CCIBPCTCS 1974. NSMNH 1991. Burnett and Hundert 1994. NSDNR 2002a and Province of Nova Scotia 2003a.b). Basemap layers (NRCan).

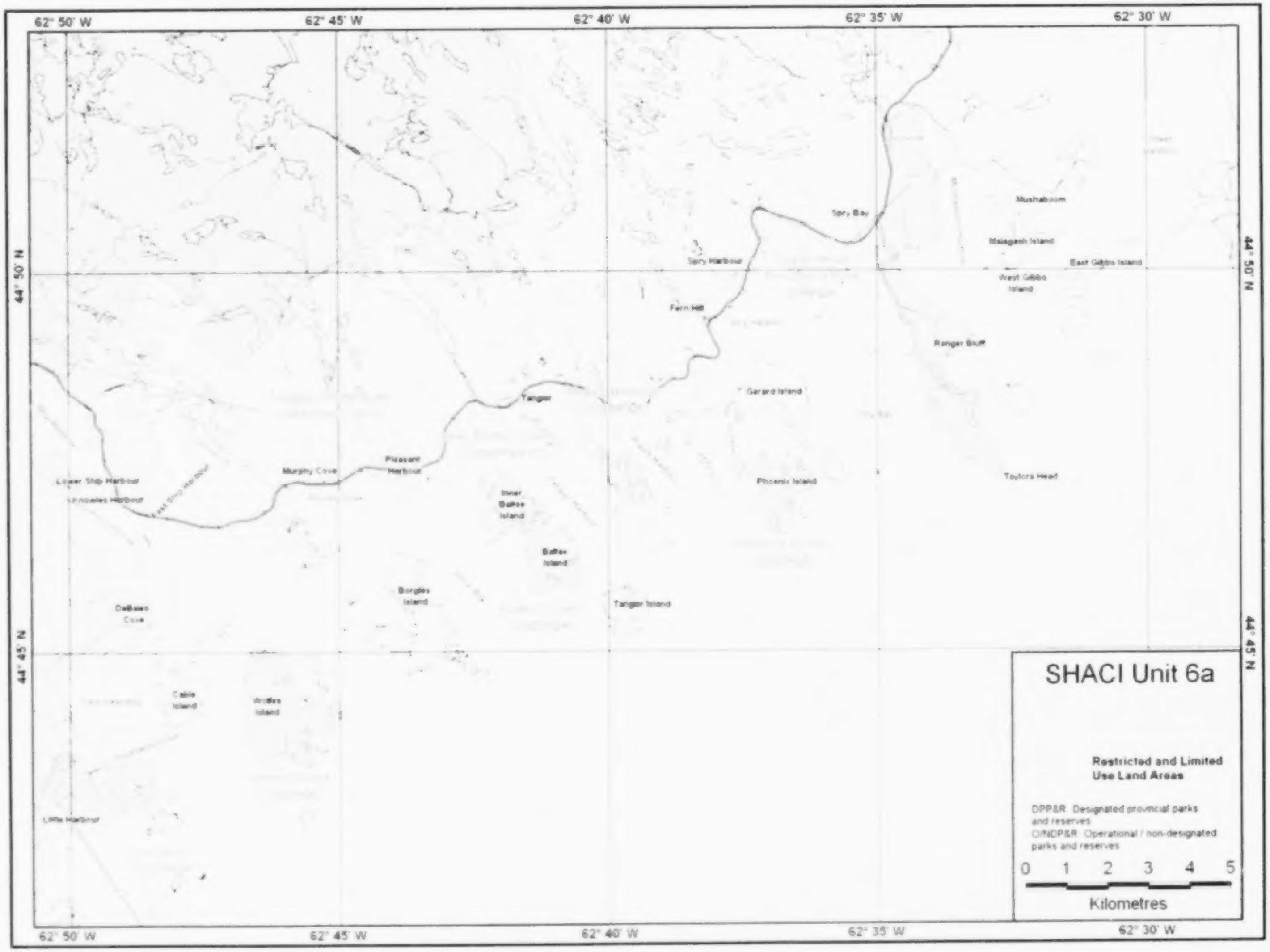


Figure 21-1f: Restricted and limited use land areas in SHACI Unit 6a (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

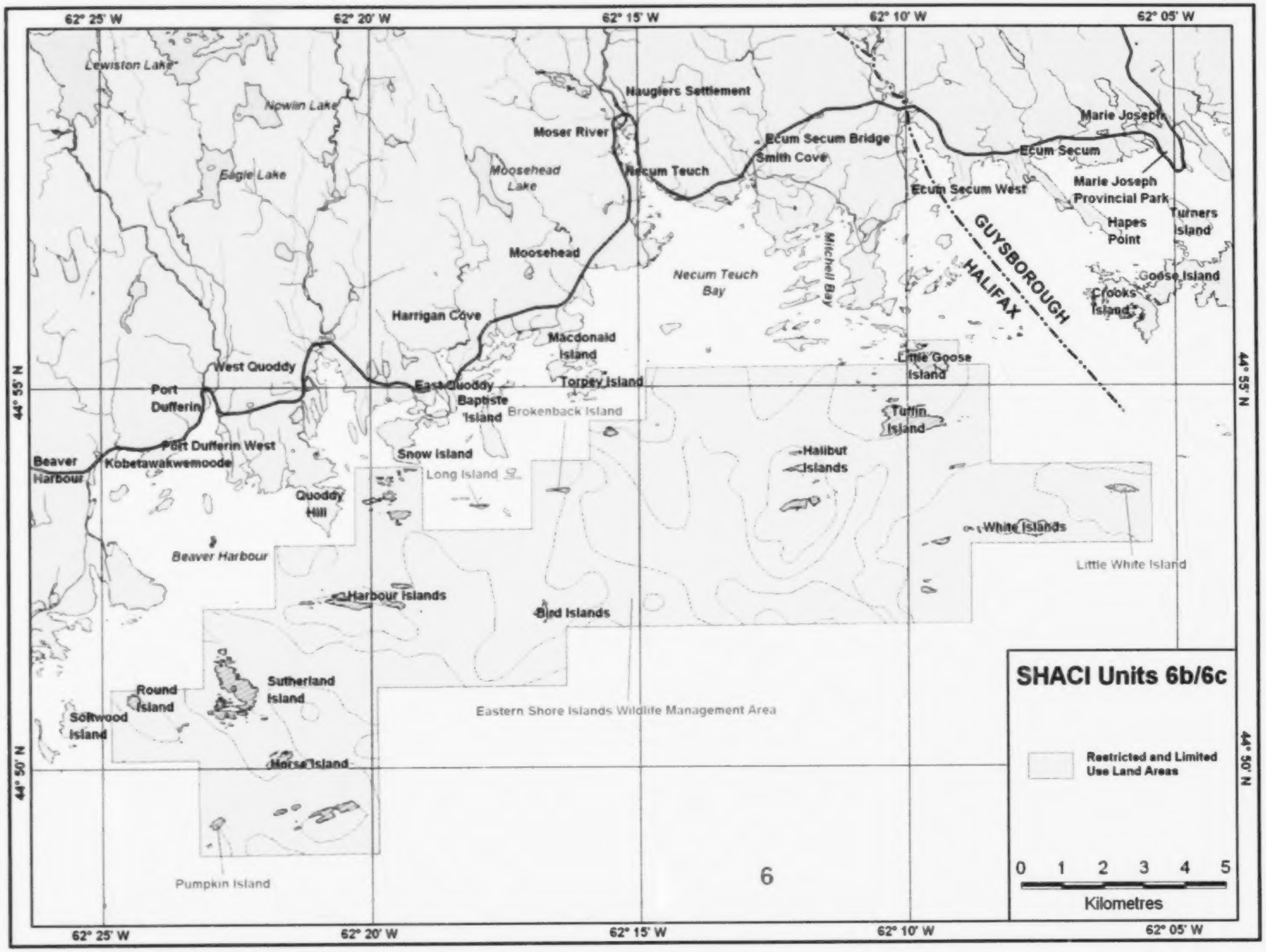


Figure 21-1g: Restricted and limited use land areas in SHACI Units 6b/6c (based on data from CCIBPCTCS 1974, NSMNH 1991, Burnett and Hundert 1994, NSDNR 2002a and Province of Nova Scotia 2003a,b). Basemap layers (NRCan).

Table 21-1: Restricted land use areas in Units 4-6

Designation	Location(s)	
Community Parks	• Admirals Park • Hemlock Ravine Park • Kidston Lake/Rockingstone Park • Moser River Seaside Park	• Point Pleasant Park • Shubie Park • Sir Sanford Fleming Park • SS Atlantic Heritage Park
Eastern Habitat Joint Venture Lands	• Cheticumchec Island • Francis Nose Island • Goose Point • Gunner Island	• Indian Island & associated islets • Lower East Chezzetcook • Nelson Conservation Area • Peter McNab Kuhn Conservation Area
Flight 111 Special Places Memorial Act	• Bayswater	• Whalesback
Indian Reserve Lands	• Cole Harbour	• Sheet Harbour
International Biological Programme	• Brokenback Island • Horse Island • Little White Island	• Long Island • Pumpkin Island • West Dover
National Historic Site	• Fort McNab • George's Island • Halifax Citadel	• Prince of Wales Tower • Sambro Island Lighthouse • York Redoubt
Nature Reserve	• Duncan's Cove	
Nova Scotia Wilderness Area	• Clattenburgh Brook • Tangier Grand Lake • Terence Bay	• Waverley Salmon River - Long Lake • White Lake
Operational/Non-Designated Parks and Reserves	• Baltee Lake • Blind Bay • Cox Lake • Fox Point • Hemlock Ravine • Herring Cove • Hubbards • Lake Charlotte • Lower East Chezzetcook Protected • Beach • Noonan's Beach	• Owls Head • Pace's Lake • Phoenix Island • Pope's Harbour • Sheet Harbour • Shubenacadie Canal • Simms Settlement • Todds Island • West Dover • Wolfes Island
Peggy's Cove Preservation Area	• Peggy's Cove Preservation Area	
Protected Beach	• Conrod's and Lawrencetown Beaches • Lower East Chezzetcook Beach • McCormack's Beach	• Noonan's Beach • Queensport Beach
Provincial Game Sanctuary	• Blandford Game Sanctuary • Martinique Beach Game Sanctuary	• Waverly Game Sanctuary
Provincial Park	• Bayswater Beach Provincial Park • Clam Harbour Beach Provincial Park • Cleveland Beach Provincial Park • Cole Harbour Lawrencetown Coastal Heritage Park • Crystal Crescent Beach Provincial Park • Hubbards Provincial Park • Judds Pool Provincial Park • Lawrencetown Beach Provincial Park • Lewis Lake Provincial Park • Long Lake Provincial Park	• Martinique Beach Provincial Park • McCormack's Beach Provincial Park • McNab's and Lawlor Islands Provincial Park • Musquodoboit Valley Provincial Park • Porters Lake Provincial Park • Rainbow Haven Beach Provincial Park • Queensland Beach Provincial Park • Taylor Head Provincial Park • William E. Degarthe Provincial Park

Table 21-1: Restricted land use areas in Units 4-6 (cont'd)

Designation	Location(s)	
Provincial Wildlife Management Area	• Eastern Shore Islands Wildlife Management Area	
Ramsar Site	• Musquodoboit Harbour Outer Estuary	
Sites of Ecological Significance	• Bear Cove • Brokenback Island • Conrad Beach • Duncans Cove • Hollahan Lake • Horse Island	• Kidston Lake • Little White Island • Long Island • Pumpkin Island • West Dover
Special Places Protection Act	• Shubenacadie Canal	
Water Supply Area – Designated	• Lake Major • Pockwock Lake	• Topsail Lake and Lake Lamont
Water Supply Areas – Non-Designated	• Chain Lake and Long Lake • Lake Fletcher • Musquodoboit River	• Shubenacadie River • Tomahawk Lake

Compiled from CCIBPCTCS 1974, NSMNH 1991, NSDNR 2002, Burnett and Hundert 1994, Province of Nova Scotia 2003a and 2003b.

Sir Sanford Fleming Park

This 54-hectare park is located on the western shore of the Northwest Arm (Unit 5), and includes the original 38 ha donated by Fleming in 1908 to commemorate the 150th anniversary of the establishment of representative government in Nova Scotia. The Dingle Tower, found within this site, was built to commemorate parliamentary institutions in the British Empire and takes its name from Fleming's summer residence, of which the park partially overlaps. Scottish-born Fleming is known for the initial survey of the Canadian Pacific Railway and his contribution towards the present world system of time zones. Fleming Park contains examples of four distinct natural habitats as well as a number of managed landscapes around the beach and tower, in addition to several walking trails. The park's forest contains spruce, pine and hemlock, and its small lake, Frog Pond, is frequently occupied by a variety of ducks, frogs and freshwater plants. The park is open year round with limited winter maintenance, and its visitor hours are between 5:00 a.m. and 10:00 p.m. (HRM 2003a, HRM 2003c).

Point Pleasant Park

This park, located at the extreme southern end of peninsular Halifax (Unit 5), comprises 75 ha of land overlooking the Northwest Arm and Halifax Harbour. Within the park are several kilometres of roads and trails providing access to the many recreational and historic resources of the park.

Point Pleasant Park houses several fortifications and batteries, including Fort Ogilvie, the Prince of Wales Tower (a national historic site described later in this document), Cambridge Battery and Point Pleasant Battery. Constructed between 1796 and 1862, they were designed to defend the adjacent water bodies and provide aircraft and searchlights. A variety of habitats are found within the park boundaries, and picnic areas are found throughout the park, which is open year round between 6:00 a.m. and 12:00 midnight (HRM 2003b).

Hemlock Ravine

Hemlock Ravine Park is an 80-hectare municipal park located in the Rockingham area (Unit 5) of the Halifax Regional Municipality, on the Bedford Basin's eastern shore. A significant feature of this park is the forested ravine for which it is named, dominated by some 250-400 year old hemlocks reaching 35 m in height (HRM 2003a, HRM 2003d). The surrounding area consists of a variety of secondary growth forests of various ages, including red spruce, red maple and other sun-tolerant deciduous species. Walking trails provide access throughout most of the park (HRM 2003a). The park area was once inhabited by two of Nova Scotia's distinguished residents: Prince Edward (father of England's Queen Victoria) and Lieutenant Governor John Wentworth. A small pond (Julie's Pond) in the park, bearing the name of Edward's mistress, reflects this history. The park is open year round with limited winter maintenance, and is open to visitors between 5:00 a.m. and 10:00 p.m. (HRM 2003d).

Admirals Park

Admirals Park is located on the eastern shore of Bedford Basin, north of the Department of National Defence's Magazine Hill (Unit 5). This area is on a quartzite ridge, and the surface is covered with quartzite boulders and exposed cliffs. It comprises a small forested area including several large white pines and other conifers (red spruce, pine and hemlock). Through the park runs a trail connecting Shore Road to Admiral Rock, giving several vantage points for viewing the Basin (HRM 2003a).

Shubie Park

This park is located in rural Dartmouth and features the Shubenacadie Canal, which runs through the middle of the park (Unit 5). The canal modified a natural waterway of chain lakes and rivers bisecting the province to accommodate commercial and passenger traffic between Halifax Harbour and Cobequid Bay at the head of the Bay of Fundy. A series of locks was constructed within the canal to navigate a drainage divide below Lake Charles and follow the traditional native route between the coasts. These well-built locks are at Wellington, Fletchers Lake, Lake Portobello, Port Wallace and Lake Banook. Lock #3 is located within Shubie Park and is the site of the Fairbanks Interpretive Centre, which houses artifacts recovered from archaeological digs and a 9 m working model of a canal lock. Guided tours are offered both inside the facility and along its many trails to outdoor archaeological sites. The Fairbanks Interpretive Centre is open from May to September (Your Halifax Buddy 2003).

The canal is bordered by forests on both sides; those on the west side include pioneer species such as birch and aspen which colonized a burnt area, while trees on the east are older and mostly hemlock, spruce and fir. Islands in the lakes at either end of the park are the best examples of the original pine forest (HRM 2003a). Hard-surfaced loop trails traverse the woods along the sides of the Shubenacadie Canal, connecting with a multi-use trail that goes from Sullivan's Pond along Lake Banook and Lake Micmac, to Lake Charles (NewEdge Technologies Inc. 2003). Shubie Park is also the site of a commercially operated campground by the same name, located on the shores of Lake Charles (Shubie Campground 2003). A wealth of recreational opportunities is available to park visitors, including paddle boat, canoe, and kayak rentals, a tour boat, canteen and picnic area (Your Halifax Buddy 2003).

Moser River Seaside Park

The Moser River Seaside Park is located at the northeast corner of the Halifax Regional Municipality (HRM), directly off Hwy #7 at the west of the river mouth which opens into the Bay of Islands (Unit 6). Comprised of approximately 2 ha, the park consists of a small, winterized public building, a WWII veterans monument, a picnic kiosk, a playground, one interpretive sign of the Moser chain lakes, and direct river frontage including a small beach. The park, maintained by the Moser River Community Association, is available year round but advance notice is required for use of the building during winter (Martin pers. comm. 2003).

Eastern Habitat Joint Venture lands

In Nova Scotia, the Eastern Habitat Joint Venture (EHJV) secures, conserves, manages, and supports sustainable use of wetlands and associated uplands that benefit wildlife and their habitats. The uplands and wetlands northeast of Halifax, long recognized as important wildlife areas and home to the Musquodoboit Harbour Outer Estuary RAMSAR site (Unit 5), constitute an important securement area to EHJV partners. All EHJV lands within this area were secured via purchase or donation under the auspices of the North American Waterfowl Management Plan (NAWMP). They are provincial Crown lands subject to the *Crown Lands Act* (1989) and terms of an Implementation Agreement between the Province of Nova Scotia and Ducks Unlimited Canada. Thus all EHJV lands are open to the public. Seven distinct areas have been secured to date under the EHJV (Table 21-2).

Table 21-2: Eastern Habitat Joint Venture lands in SHACI Unit 5

General area	EHJV land	Area (ha)
Cole Harbour	Peter McNab Kuhn Conservation Area	1916
	Nelson Conservation Area	164
Musquodoboit Harbour	Cheticumchec Island	27
	Francis Nose Island	188
	Goose Point Island	2.4
	Indian Island and associated islets	30
	Gunners Island	37
Lower East Chezzetcook	Lower East Chezzetcook	130

Flight 111 Special Places Memorial Act

This *Act* commemorates the crash of SwissAir Flight 111 by establishing three special memorial places, all of which are located within Unit 4. One is the approximate crash site in the Atlantic Ocean at 44°24' 33" north latitude and 63°58' 25" west longitude, near Peggy's Cove. The second is a memorial and burial site at Bayswater, Lunenburg County, and the third is a memorial site at Whalesback, Halifax Regional Municipality (*Flight 111 Special Places Memorial Act* 1999).

Indian reserve lands

According to the *Indian Act* (1985) Indian reserve lands are reserves held by Her Majesty for the use and benefit of the respective bands for which they were set apart. Subject to this *Act* and to the terms of any treaty or surrender, the Governor in Council may determine whether any purpose for which lands in a reserve are used or are to be used is for the use and benefit of the band.

Only two Indian reserve lands are located near HRM's Atlantic shore, Cole Harbour (Unit 5) and Sheet Harbour (Unit 6). They are two of four land holdings that comprise the Millbrook Reserve, which is occupied by the Millbrook First Nation community, part of the Mi'kmaq Nation (Millbrook First Nation 2003). The Cole Harbour Reserve (#30) is 9.6 km east of Halifax and occupies 18.6 ha. This reserve, home to 38 residents in 2001, has lost 24% of its population since 1996 (Statistics Canada 2003). The Sheet Harbour Reserve (#36) is located 50 km east of Musquodoboit and occupies 32.7 ha. It is home to 34 residents, 46% fewer than in 1996 (INAC 2003, Statistics Canada 2003).

International Biological Programme

The International Biological Programme (IBP) was adopted by 58 nations to study the biological productivity of the earth and relate this to human adaptability and welfare. The Conservation of Terrestrial Communities Section (CT) of the IBP was focused on preserving samples of the world's ecosystems for present and future biological research, as datum points by which to measure anthropogenic changes in ecosystems, and for educational and demonstration purposes. In the Maritimes region, the Canadian IBP-CT identified 110 natural areas to be considered for protected status as Ecological Reserves (CCIBPCTCS 1974). These sites, however, have no legal designation through the IBP-CT.

The IBP surveyed and inventoried significant terrestrial habitats from the late 1960s until 1974, identifying five such locations within SHACI Unit 6. Their profiles are presented below.

Brokenback, Horse, Little White, Long, and Pumpkin Islands
These five islands are located at the outer margin of the Bay of Islands in SHACI Unit 6, straddling the Halifax/Guysborough county line. They range in size from 4-8 ha and all are provincial Crown lands except Horse Island, which is privately owned (Ogilvie pers. comm. 2003). All five are rugged and undisturbed islands; Brokenback and Long Islands are made up of separate islands connected by a barrier beach and rock reef, respectively. The flora of these islands ranges from representative coastal forest (white spruce and balsam fir) at Brokenback, Horse and Long islands to treeless, consisting instead of herbs, ferns, shrubs and low grasses at Little White and Pumpkin Islands. Habitat types include coastal forest, open sea, unprotected rock slopes, and rock cliffs,

Brokenback, Horse, Little White, Long and Pumpkin Islands are recognized for their importance as bird habitat by several organizations. The International Biological Programme recognized the important bird nesting sites, particularly for the Black Guillemot, Common Eider, Double-crested Cormorants, Fox Sparrow, Leach's Storm Petrel, and Osprey as attributes of exceptional interest (CCIBPCTCS 1974). They were also recognized as Sites of Ecological Significance (NSMNH 1991) and Important Bird Areas (BSC 2003a), and are included within the Eastern Shore Wildlife Management Area (NSDOJ 2003).

National historic sites

Canadian national historic sites are administered by Parks Canada and are part of Canada's program of historical commemoration, which recognizes nationally significant places, persons and events. Commemorations are essentially an expression of the public's identification of significant aspects of our history. Recently, the view of what constitutes heritage has broadened considerably to include industrial complexes, transportation corridors, urban and rural historic districts, cultural landscapes, and sacred places and traditions (Parks Canada 2000a).

The Minister of Canadian Heritage makes all designations under this program on the advice of the Historic Sites and Monuments Board of Canada. Parks Canada's Cultural Resource Management Policy affirms that all cultural resources are managed according to the five principles of value, public benefit, understanding, respect and integrity (Parks Canada 2000a).

Most commonly, a national historic site is commemorated by a plaque or a simple marker; however, some designated sites are commemorated through acquisition by the federal government for protection and presentation to the people of Canada, or by means of a cost-sharing agreement. The federal government's objective in these investments is to ensure the commemorative integrity of these outstanding places (Parks Canada 2000a).

There are six national historic sites throughout SHACI Units 4 and 5, and none in Unit 6. Five of the six sites – Fort McNab, Georges Island, Halifax Citadel, Prince of Wales Tower and York Redoubt – are located in Unit 5 and are part of a series of military fortifications known as the Halifax Defence Complex. This system is recognized as unique on the North American continent because it contains a complete conspectus of shore defences from the mid-18th century to the Second World War (Parks Canada 2003a). The Sambro Island Lighthouse (Unit 4) is the sole local national historic site not directly affiliated with the military.

Fort McNab National Historic Site

This Fort was built between 1888 and 1892 on the strategically important south end of McNab's Island near the mouth of Halifax Harbour. Throughout its active duty, Fort McNab served as a key element of harbour defence. It housed a gun battery and the port's Examination Station; soldiers stationed there were responsible for ensuring that visiting ships did not pose a risk to port security (Parks Canada 2000b).

Source: Parks Canada 2003b

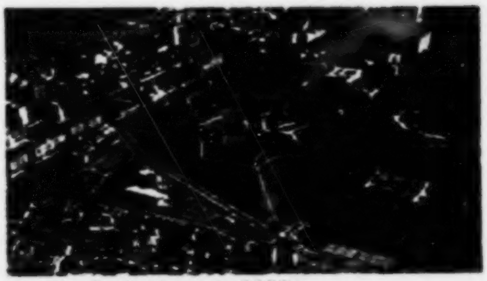
The Fort was decommissioned in 1959 and is now open to visitors at McNabs Island for no entry fee. A network of old roads and rough trails connects this national historic site to the rest of the island, most of which is encompassed within McNab's and Lawlor's Provincial Park (Parks Canada 2003b). McNab's Island can be accessed year round via private or commercially operated boats.

George's Island National Historic Site

George's Island is a small drumlin located in the middle of Halifax Harbour that was shaped by glacial action thousands of years ago. It served as the heart of seaward defences for Halifax's important naval base, and saw nearly constant military activity for almost 200 years. Changing military technology reduced its usefulness to the Department of National Defence, and today Parks Canada is preparing this heritage site for future visitation (Parks Canada 2003c).

Source: Parks Canada 2003c

Halifax Citadel National Historic Site



Source: Parks Canada 2003a

The Halifax Citadel is located at the top of a small drumlin on the Halifax peninsula, overlooking Halifax Harbour. Formerly a key component of the Halifax Defence Complex, it has been "commemorated as a nationally significant symbol of Halifax's role as a principal naval station in the British Empire and of the city's importance to Canada's development and evolution from colony to nation" (Parks Canada 2003a). Today, the Halifax Citadel is one of the most important historic sites in Canada and a cultural treasure visited by tens of thousands of visitors annually. The grounds are open year round, and daily entry fees vary by season, age and group class up to a $9 maximum per person. Hours of operation are typically 9 a.m. to 5 p.m. (Parks Canada 2003a).

The Halifax Citadel offers a wide variety of services, activities and learning experiences to visitors, including meeting and event facilities, the Soldiers' Library, a Parade Square, an excellent natural amphitheatre, a costumed interpretive program and guided tours. Other services include a School Days program for local children, an Army museum, exhibits and a Living History program (Parks Canada 2003a).

Prince of Wales Tower National Historic Site

Located in Point Pleasant Park at the southern tip of the Halifax Peninsula, the Prince of Wales Tower was built in 1796-1797 to protect British batteries from French attack. It was the first tower of its type in North America, and presently contains exhibits portraying its history, architectural features and significance as a defensive structure. The Prince of Wales Tower is open to the public, free of charge, between July 1 and September 7 from 10:00 a.m. to 6:00 p.m. Point Pleasant Park offers ample free parking, washrooms and picnic tables, and is used for a variety of recreational activities (Parks Canada 2003d).

York Redoubt National Historic Site

Source: Parks Canada 2003e

York Redoubt was established in 1793 on a bluff overlooking the entrance to Halifax Harbour, and subsequently expanded to become a key element in the Halifax Defence Complex. Located approximately 20 minutes from downtown Halifax, York Redoubt displays 200 year old armaments and fortifications indicative of its former military role. This site offers scenic views of the harbour mouth and adjacent coastline as well as a Second World War Command Centre. Ample free parking, washrooms and picnic tables are available on the grounds, which are wheelchair accessible with assistance (Parks Canada 2003e).

Sambro Island Lighthouse National Historic Site

The Sambro Island Lighthouse stands on a rocky island approximately 2 nm from the entrance to Halifax Harbour, marking a region of more than 30 dangerous shoals (NSLPS 2003a). It was first lit in 1760 and today is the oldest working lighthouse in North America, standing 22.5 m from base to vane. The lighthouse was designated classified for its historical associations, environmental significance, and architectural design (NSLPS 2003b). The 1906 installation of a special dioptric lens from France marked the tower as one of Canada's major coastal beacons, and its present airport beacon has a range of nearly 39 km. Sambro Island is accessible by boat from Ketch Harbour (NSLPS 2003a).

Nova Scotia wilderness areas

The Nova Scotia government designates Wilderness Areas under the *Wilderness Areas Protection Act* (1998). Areas are selected as representative samples of natural landscapes and ecosystems. This *Act* ensures that ecological integrity, natural ecological processes and biodiversity are maintained in the designated areas. Wilderness Area designation does not extend into the water (R. Milton pers. comm. 2002). Traditional sport fishing and hunting are still permitted in Wilderness Areas (McEachern 1997), and in exceptional circumstances intervention by habitat manipulation or other means is permitted if native biodiversity is at risk (D. MacKinnon pers. comm. 2002). Some areas are designated both as WMAs and Wilderness Areas. In such cases, the more robust Wilderness Area protections largely override those of the WMA designation (D. MacKinnon pers. comm. 2002).

Five wilderness areas are found throughout Units 4-6, all of which are described below.

Clattenburgh Brook Wilderness Area

Clattenburgh Brook is a large (1911 ha) tract of forest, bog and barren ecosystems located a few kilometres north of the northern tip of Porters Lake (Unit 5). The wilderness area designation protects the ecosystems of the Quartzite Hills and Plains natural landscape, in which changes in bedrock are reflected by changes in the overlying ecosystems (NSDEL 2003a). Meguma group bedrock of this area forms large-scale folds, characteristic of the Clattenburgh Brook area. Sharp, regional-scale hinges result in sub-parallel ridge/swale units. These repeating parallel ridges are dominated by dry barrens, with thin to absent soils supporting woody shrubs, lichens and stunted trees where soil permits (NSDEL 2003a).

Tangier Grand Lake Wilderness Area

This wilderness area, located in the eastern portion of HRM between Ship Harbour and Moosehead (Unit 6), protects 16 000 ha of rugged conifer forest wilderness endowed with lakes, waterways and wildlife. This area typifies Nova Scotia's Eastern Shore Granite Ridge natural landscape; the rugged lake-rich local character indicates the recent glaciation history of the area. Tangier Grand Lake is the most prominent feature of the area and the largest lake in the province without direct road access. This near-coastal wilderness is well known for its trout fishing and canoe-tripping opportunities, and ancient, traditional waterway routes can be followed well beyond the area's boundaries (NSDEL 2003b).

Terence Bay Wilderness Area

This wilderness area is a "rugged, 4 450 hectare coastal and near-coastal wilderness within a rapidly urbanizing portion of HRM (Unit 4). Together with the adjacent Long Lake Provincial Park, it forms a nearly 20 km natural corridor between Spryfield (suburban Halifax) and the Atlantic Ocean." The lakes, woodlands and coastal environment of this wilderness area offer excellent opportunities for wilderness recreation in a near-urban area (NSDEL 2003c).

Much of this area is representative of Nova Scotia's Pennant Coastal Barrens natural landscape, stretching between Peggy's Cove and Halifax Harbour. The rugged, granite-defined terrain is consistently forested with mixtures of spruce, fir, maple, birch and white pine, and lakes and streams are common throughout (NSDEL 2003c). Recreational pursuits practised within and beyond the Terence Bay area include coastal kayaking and other boating, hiking along informal trails, angling, hunting , rock climbing, bouldering and many others (NSDEL 2003c).

Waverley - Salmon River Long Lake Wilderness Area

This large (8710 ha) wilderness area (Unit 5), located northwest of Porters Lake has a rugged terrain marked by lakes, barren hills and pockets of old-growth pine and hemlock. At its western margin, this wilderness area overlaps with the watershed of Lake Major, a designated water supply area for HRM, and part of the Waverley Game Sanctuary. In the north of this wilderness area, a ridge and swale pattern orients northeast on Meguma group quartzite and slate bedrock, while in the south, chains of clean lakes, rivers and wet forests cross gullies between high ridges. This area provides excellent views and destination points for rugged wilderness hiking, and over 30 km of canoe routes into the remote interior (NSDEL 2003d).

White Lake Wilderness Area

Located just north of Musquodoboit Harbour and immediately east of the lower Musquodoboit River, this wilderness area (Unit 5) represents the Eastern Shore Granite Ridge landscape and protects 4540 ha of rugged, lake-covered and conifer forest wilderness. The rough parallel ridges and knobs in the granite bedrock define the character of over 20 interconnected lakes, many of which are enjoyed by anglers and canoe trippers. A high quality wilderness hiking trail system is being developed and managed by Musquodoboit Trailways Association, through agreements with provincial departments and a private landowner (NSDEL 2003e).

Operational/non-designated parks and reserves

These provincial parks are not designated under legislation but are generally open for public use unless otherwise noted. Non-designated provincial park/park reserve properties are administered under the *Crown Lands Act* (1989) (Kinsman pers. comm. 2003). Limited information is available on these areas apart from their area and operational status (Table 21-3). Profiles are provided for those sites with more information.

Peggy's Cove Preservation Area

Peggy's Cove Preservation Area was established by the *Peggy's Cove Commission Act* of 1963. This *Act* created the Peggy's Cove Preservation Area and the Peggy's Cove Commission, whose purpose is to "preserve the unique scenic beauty, character and atmosphere of the Area for the enjoyment of both residents and visitors" (*Peggy's Cove Commission Act* 1989). To do this, the Province purchased all privately held lands within the Area outside the village of Peggy's Cove, and controls the erection, use, occupancy, construction, alteration, repair, destruction or demolition of all buildings within the Area (Newbould pers. comm. 2003). The construction of buildings outside the village is prohibited. The village has a year round population of 45 residents and is the focus of one of Canada's largest tourist attractions, receiving approximately 750 000 visitors annually concentrated in the summer season (eTourist Network 2003, Manuel pers. comm. 2003). Traditional paths once used predominantly by locals are increasingly used by tourists, threatening the fragile landscape (Manuel pers. comm. 2003, Newbould pers. comm. 2003). Concern over this high tourist traffic has sparked a study by the Nova Scotia Department of Tourism and Culture to determine how to preserve the community's integrity while accommodating visitors (eTourist Network 2003).

Table 21-3: Operational and non-designated provincial parks and park reserves (Kinsman pers. comm. 2003)

Name	Open to . public	Size (ha)	Notes
Baltee Island	No	148	May be included in an expansion of the Eastern Shore Islands Wildlife Management Area.
Blind Bay Provincial Park Reserve	No	185	
Cox Lake Provincial Park Reserve	No		
Fox Point Provincial Park Reserve	No		
Hemlock Ravine Provincial Park Reserve	Yes	47.5	Leased to HRM which operates this property as a municipal park. See "Community Parks" for more information.
Herring Cove Provincial Park Reserve	Yes	19	Site hosts informal trails, public uses the property.
Hubbards Provincial Park	Yes	0.4	Boat launch site, not designated under Parks Act.
Lake Charlotte Provincial Park Reserve	No	750	Located almost entirely north of Highway 7, this site has no coastal frontage.
Lower East Chezzetcook Provincial Park Reserve	No	33	A different property than the Lower East Chezzetcook Protected Beach.

Noonan's Beach	Yes	N/A	Also a Protected Beach.
Owls Head Provincial Park Reserve	No	277	
Paces Lake Provincial Park Reserve	No	425	North of Highways 107 and 7, includes no coastal frontage.
Phoenix Island	No	162	May be included in an expansion of the Eastern Shore Islands Wildlife Management Area.
Popes Harbour Provincial Park Reserve	No	81	
Sheet Harbour Provincial Park Reserve	No	12	
Shubenacadie Canal Provincial Park Reserve	Yes	10	Core property includes the Fairbanks Interpretive Centre; the Reserve also includes several other smaller parcels on the canal.
Simms Settlement Provincial Park Reserve	No	19	Divided by Highways 103 and 3, no coastal frontage.
Todds Island Provincial Park Reserve	No	1.6	
West Dover Provincial Park Reserve	Yes	1008	Also a Site of Ecological Significance, and overlaps with the Peggy's Cove Preservation Area. See those sections for more detail.
Wolfes Island	No	378	May be included in an expansion of the Eastern Shore Islands Wildlife Management Area.

Protected beaches

Protected beaches are those designated by regulation under the Nova Scotia *Beaches Act* (1989). The general intent of this *Act* is to provide for the protection of beaches and associated dune systems, to regulate land uses on beaches (for example aggregate removal), and to regulate recreational and other uses of beaches. There are seven protected beaches found on the shores of SHACI Units 4-6: Fox Point Beach, Black Point Beach, Conrod's Beach and Lawrencetown Beach, Lower East Chezzetcook Beach, McCormack's Beach, Noonan's Beach and Fancy's Beach. Those beaches for which descriptive information is available are profiled below in the order in which they are encountered travelling northeasterly from Blandford.

Fox Point Beach

This is a separate property from the Fox Point Provincial Park Reserve.

Conrod's Beach and Lawrencetown Beach

These beaches form part of the Cole Harbour - Lawrencetown Coastal Heritage Provincial Park System (Unit 5), and are consequently also designated under the *Provincial Parks Act* (1989). See the Provincial Park section for more information on these beaches.

Lower East Chezzetcook Beach

This Beach is situated on a different property than the Lower Chezzetcook Provincial Park Reserve (Kinsman pers. comm. 2003).

McCormack's Beach
This protected beach also forms part of the undesignated, operational McCormack's Beach Provincial Park. It offers parking, beach access, picnicking and wheelchair accessible trails. The entire park is 3 ha (Kinsman pers. comm. 2003).

Noonan's Beach
No facilities or services are provided at this beach (Kinsman pers. comm. 2003).

Provincial game sanctuary

Three game sanctuaries are located throughout SHACI Units 4-6: Blandford Game Sanctuary, Waverly Game Sanctuary and Martinique Beach Game Sanctuary.

Martinique Beach Game Sanctuary
This sanctuary includes "most of the aquatic and intertidal areas within the seaward portion" of Musquodoboit Harbour (Unit 5). It is closed to boaters and clam diggers between Labour Day weekend and April 15 of each year to allow populations of breeding, migratory and wintering birds to feed undisturbed (see Marine Birds section). The local and surrounding area has also been identified as an Important Bird Area for its Continentally Significant populations of Canada Geese and American Black Duck, and waterfowl banding stations are operated annually onsite (BSC 2003b).

Provincial parks

Provincial Parks are provincially owned lands that are listed and managed under the *Provincial Parks Act* 1989. They provide areas for outdoor recreation and are meant to achieve conservation objectives (Burnet and Hundert 1994, Nova Scotia 2000). Several of these areas are simply picnicking areas, however others have additional features.

Nova Scotia Provincial Park regulations prohibit (among others) the removal or damage of any flora, the removal of any artefacts, excavations, and the alteration, damage or destruction of any watercourse unless a permit is issued by the Minister. Domestic pets must be kept on a leash and horses may only be present in designated areas. Hunting is not permitted without written permission from the Minister, however, fishing within Provincial Parks is as authorized under the *Wildlife Act* or regulations. Vehicles may only be operated in designated areas and the general public is not permitted to operate off-highway vehicles in Provincial Parks. Fines for violating Provincial Park regulations range between $50 and $2000 (Province of Nova Scotia 1999).

Nineteen (19) provincial parks are located in or associated with coastal areas within SHACI Units 4-6. Several of these areas are simply picnic areas but many have several additional features. Most provincial parks are described below but not all, depending on the availability of information about each park. Most parks are also open between mid-May and mid-October unless otherwise noted.

Bayswater Beach Provincial Park
This 5-ha park is located on the eastern shore of the Aspotogan peninsula (Unit 4), approximately 20 km south of Highway 103 at exit 7. Bayswater beach has a picnic area with barbeque grills, a large sand beach and a view of the open ocean (NSDNR 2000, NSDNR 2002b).

Queensland Beach Provincial Park
Queensland Beach is located at the inside edge of the Aspotogan peninsula where Halifax and Lunenburg Counties meet, just east of Hubbards (Unit 4). This 1-ha supervised white sand beach is among the most popular on Nova Scotia's South Shore, and offers a picnic area. The park is generally open from late June to late August (NSDNR 2000, NSDNR 2002b, HRM 2003a).

Cleveland Beach Provincial Park
This 4-ha park is very close to Queensland Beach and includes a picnic area and unsupervised sandy beach (Unit 4). Cleveland Beach is wider than Queensland Beach because it faces a protective headland. The headland supports a wide variety of common native flowers including Queen Anne's lace, beach pea, pasture rose and thistle. The trail along this headland offers good views of the Aspotogan peninsula, adjacent islands and the variety of waterfowl inhabiting the bay's sheltered waters (NSDNR 2000, NSDNR 2002b, HRM 2003a).

William E. Degarthe Provincial Park
This park is located in and around Peggy's Cove (Unit 4), offering views of plunging breakers and high surf conditions. These and other mechanical weathering processes created the adjacent harbour of Peggy's Cove (HRM 2003a).

Lewis Lake Provincial Park
Lewis Lake Provincial Park (Unit 4) surrounds one of the many small lakes in the Granite Uplands region at Upper Tantallon, just a few kilometres west of Halifax. This 150-ha park includes an area designed to accommodate the special needs of seniors and the physically challenged, with wheelchair trails and accessible picnic tables under a mixed wood forest. The lake is stocked with brook and rainbow trout for recreational fishing, and a fishing wharf and viewing spots are available for visitor use (NSDNR 2002b, HRM 2003a, NSDTC 2003).

Crystal Crescent Beach Provincial Park
Crystal Crescent Beach (Unit 4) is named for its three white-sand crescent-shaped beaches that are fully exposed to the open Atlantic. Located just west of Sambro, it also serves as the trailhead for a 10 km one-way hike to Pennant Point. No services are provided at this park, and its waters are cold year round but it remains a popular summer beach for sunbathers, both clothed and nude. This park is operated by the Province of Nova Scotia and the Greater Chebucto Community Development Association, and generally remains open between mid-May and mid-October (NSDTC 2003).

Long Lake Provincial Park
This site is a good example of the Acadian forest typical of the Granite Uplands, with deciduous and coniferous trees intergrading along some slopes and climax hardwood forest found on others.

This unmanaged provincial park once served as a designated water supply area for the city of Halifax, and is now an increasingly popular destination for hiking and mountain biking due to its network of unofficial trails within the forest and along the shores of Long Lake. The one official access point is a small municipal lot on the St. Margarets Bay road, although several others are regularly used. The development of this park is being worked out between the Department of Natural Resources and the Friends of Long Lake Provincial Park Association (HRM 2003a).

McCormack's Beach Provincial Park

This park, adjacent to popular Fisherman's Cove, provides a few picnic shelters, and affords beautiful views of Eastern Passage, Lawlor's and Devil's Islands, and Halifax Harbour. These views are available along an extensive boardwalk tour of the salt marsh developing behind the islands from sediment eroding from the drumlins (HRM 2003a).

McNabs and Lawlor Islands Provincial Park

McNabs and Lawlor Islands were designated as a Nova Scotia Provincial Park on November 4, 2002. The park is located on the western boundary of the Eastern Shore Beaches landscape, one of 80 natural landscapes in Nova Scotia. As part of the planning process for Nova Scotia's Protected Areas System Plan, the islands were identified as providing good representative.of the inshore drumlin islands that are found in this landscape dominated by beaches, salt marsh, headlands, and islands (NSDNR 2002c). Its size and configuration supports a variety of coastal and inland forest habitats, ranging from a typical coastal white spruce and balsam fir along the shore to an Acadian forest of beech, birch and sugar maple and significant stands of near old-growth red oak on the hill tops. The island also hosts a heronry and nesting sites for eagles, Osprey and migrating songbirds. It is a popular local destination and can be accessed by one of several ferry services or private boat, which may land at the island's unmaintained wharf, sheltered harbour or any of several sand beaches (HRM 2003a). McNabs Island also hosts Fort McNab National Historic Site, described previously in this section.

Rainbow Haven Beach Provincial Park

This 29-ha park, known for its large sand and cobble beach, is located 8 km east of Cow Bay at the mouth of Cole Harbour. The park has boardwalks for beach access, facilities for the disabled, a supervised swimming area, canteen and a change house with toilets. Rainbow Haven Beach is generally open between late June and late August (NSDNR 2002b, NSDTC 2003).

Cole Harbour – Lawrencetown Coastal Heritage Park System

The Cole Harbour – Lawrencetown Coastal Heritage Park, which became a provincial park in early 1999, provides access to a range of coastal landscapes including sandy beaches, coastal salt marshes, eroding headlands and wildlife habitat (NSDNR 2002b). This park system includes the Atlantic View Trail, linking Rainbow Haven Beach, Cole Harbour and Lawrencetown Beach Provincial Park (HRDA 2003).

Lawrencetown Beach Provincial Park

Located approximately 20 km east of Dartmouth, the main feature of this large (246 ha) provincial park is its sand and cobble beach exposed to the open Atlantic. Ideal surf conditions are found at this beach, making it popular with surfers year round. Swimmers are supervised during summer months and cautioned against strong local rip tides and undertow currents. The park also hosts a canteen, shower, and toilet facilities, connected to the beach via ramped boardwalks. The Atlantic View Trail is accessible from the park, providing good views of the dunes to the east and across the causeway to the west; on clear days Chebucto Head can be seen from the top of a nearby drumlin (NSDNR 2000, HRM 2003a).

Porters Lake Provincial Park

This 87-ha park is located on the western shore of this large freshwater lake, just east of Dartmouth. The park offers a small beach, picnic grounds and 158 campground sites on open and wooded grounds. One site is wheelchair-accessible and group sites are available. Visitor amenities include flush toilets, showers, a disposal station, fire grills, firewood and boat launch. A range of outdoor activities can be pursued within the park, including canoeing, water skiing, fishing and swimming at an unsupervised beach. The park is open from mid-June to early September at daily rates of $18 (NSDNR 2000, NSDNR 2002b, HRM 2003a).

Martinique Beach Provincial Park

Located 10 km south of Musquodoboit, this 60-ha park is the site of a beautiful natural sand dune system. Martinique is one of the largest crescent beaches in Nova Scotia and creates a barrier between the Atlantic and the protected lagoon and marshes behind. It is one of only five sites in HRM where the endangered Piping Plover nests, and visitors are cautioned to avoid these birds during their stay between May and August (NSDNR 2000, HRM 2003a). Beachcombing and bird watching are popular at this beach, and the park offers open and wooded picnic areas, change houses, boardwalks and hard-surfaced paths (NSDTC 2003). Martinique Beach Provincial Park is adjacent to the Martinique Game Sanctuary and overlaps the Musquodoboit Important Bird Area (see Martinique Game Sanctuary).

Clam Harbour Beach Provincial Park

This is a large (180-ha) park, and its central attraction, Clam Harbour Beach, is sandy, long and wider than most barrier beaches along the Eastern Shore, hosting annual sand castle building contests. Showers, changing rooms, flush toilets and a canteen are available on-site, and swimming is supervised on weekends. A picnic area is provided at the top of a bluff, and boardwalks pass between the dunes (NSDNR 2002b). The park also hosts an interpretive display and a trail system (HRM 2003a).

Spry Bay Provincial Park

Spry Bay is a small roadside park overlooking Spry Bay, just east of Spry Harbour (NSDTC 2003).

Taylor Head Provincial Park

Taylor Head, Nova Scotia's largest provincial park, juts out over 6 km into the Atlantic and offers over 16 km of unspoiled coastline, secluded beaches and trails with scenic lookoffs. Located 11 km west of Sheet Harbour, it is between Spry Bay to the west and Mushaboom Harbour to the east. This peninsula's natural landscape consists of cobble beaches, sand dunes, and spruce/fir forests and wind swept barrens along rocky headlands. It also features several geological features, a variety of wildlife and diverse habitats. Gulls, terns, cormorants and other seabirds nest on the island, which also supports white-tailed deer, a variety of small mammals and lichen-covered rocks. The park hosts five challenging hiking trails ranging from 2-8 km return distance, and several small picnic areas, change houses and boardwalks to the white sand beach for unsupervised swimming. Specialized facilities are provided for wheelchair users (NSDNR 2000, NSDNR 2002b, NSDTC 2003).

Judds' Pool Provincial Park Reserve

This 80-ha park reserve is located on the Ecum Secum River in Guysborough County, and has no coastal frontage. A former picnic park closed several years ago, it is now a park reserve (Kinsman pers. comm. 2003).

Provincial wildlife management areas

Eastern Shore Islands Wildlife Management Area

The Eastern Shore Islands are located roughly between Clam Harbour and Ecum Secum, within Unit 6. The management area includes approximately 50 low vegetated inshore islands and islets and 10 non-vegetated islets or ledges located between 2 and 15 km offshore. The islands include Round, Speck, Sutherland, Pumpkin, Horse, Brother, Harbour, Beaver, Flag, High, Brokenback, Bird, Gold, Halibut, Little Goose, Puffin, Frying Pan, Camp, White and Little White (Payne 1977, BSC 2003a). The Wildlife Management Area designation protects these islands from undue human disturbances. Landing on the islands is prohibited from April 1 through August 15 of any year to anyone except local inshore commercial fishermen and persons with written permission from the provincial Minister for the Department of Natural Resources. This includes licensed waterfowl hunters during open season (NSDNR 1997).

Eastern Shore Islands is also designated an Important Bird Area for its Globally and Continentally Significant Common Eider (*Somateria mollissima spp. dresseri*), and Nationally Significant Harlequin Duck (*Histrionicus histrionicus*) populations (see Marine Birds section) (BSC 2003a).

Ramsar sites

Musquodoboit Harbour Outer Estuary

The Convention on Wetlands, signed in Ramsar, Iran in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and and wise use of wetlands and their resources. Musquodoboit Harbour is one of eight RAMSAR sites located throughout the Atlantic provinces and the only one within SHACI's geographic domain. The site is located at the outer estuary of Musquodoboit Harbour, covers approximately 1925 ha and overlies both the Martinique Beach Provincial Park and Game Sanctuary. It is composed of eelgrass, sand and mud flats, sand beaches and beach grass, intertidal estuarine waters and marshes, as well as scattered upland islands. Key habitat areas outside the provincial park and game sanctuary are protected through the EHJV program. The site is a highly significant coastal landscape with high recreational use, threatened by naturally eroding sand dunes that protect it from the open ocean and inland development (Environment Canada 2003).

Sites of ecological significance

Sites of ecological significance are sites recognized by the Nova Scotia government as areas containing rare or endangered plants or animals in their natural habitats, and those that are representative examples of natural ecosystems within the Province. These "Sites" have no legal protection at this time unless provided by another designation but under provincial policy, such sites on Crown land are under a development moratorium (NSMNH 1991, MacKinnon pers. comm. 2003).

SHACI Units 4-6 hosts 11 such sites – Brokenback, Horse, Little White, Long and Pumpkin Islands, Bear Cove, Conrad Beach, Duncans Cove, Hollahan Lake, Kidston Lake and West Dover. The island sites were previously described under the International Biological Programme section, and the remainders are profiled below except for Kidston Lake which is described in the Community Parks section, and Duncans Cove which is described in the Nature Reserves section.

Bear Cove

Situated on 8 ha of private land, this is a small but good example of a coastal bog, with a diverse flora, including orchids and the curly-grass fern, *Schizaea pusilla* (NSMNH 1991).

Conrad Beach

This 35-ha site, situated within the provincial park of the same name, is a good example of dune succession near Halifax. The beach itself serves as habitat for the rare Moonwort Grape-fern (MacKinnon pers. comm. 2003), and the extensive salt marsh landward of this beach is a feeding area for birds such as the Great Blue Heron, Osprey, Bald Eagle and geese (NSMNH 1991).

Hollahan Lake

This 4-ha area was proposed as an ecological site under the International Biological Programme (Davis and Browne 1996) and is recognized as a Site of Ecological Significance by the province of Nova Scotia (NSMNH 1991). It has not been designated as a nature reserve under the *Special Places Protection Act* (1989) yet, although the NSDNR's Integrated Resource Management process classified it as a Protected & Limited Use Lands. The Hollahan Lake site is a good illustration of Jack Pine forest development following a major fire (MacKinnon pers. comm. 2003).

West Dover

This 182-ha site, partly overlapping Peggy's Cove Preservation Area, is characterized by a mosaic of lichens on bare rock, low shrub heath on well-drained slopes, and bogs and ponds in hollows in a virtually treeless environment. The granite bedrock has been moulded into interesting shapes by glaciation, and the wind influence on vegetation (krummholz) is well illustrated in this environment. The geomorphology at this location, including roches moutonees and perched erratics, is rarely observed this far south of the arctic, contributing to the great scenic value of this landscape (CCIBPCTCS 1974).

Special Places Protection Act

The Nova Scotia *Special Places Protection Act* (1989) provides for the preservation, protection, regulation, exploration, excavation, acquisition and study of archaeological and historical remains and palaeontological sites that are considered important parts of the natural or human heritage of the province. It also provides for the preservation, protection, regulation, acquisition and study of ecological sites that are considered important parts of the natural heritage of the Province. Ecological sites under this *Act* are sites that:

- are suitable for scientific research and educational purposes;
- are representative examples of natural ecosystems within the Province;
- serve as examples of ecosystems that have been modified by man and offer an opportunity to study the natural recovery of ecosystems from such modification;
- contain rare or endangered native plants or animals in their natural habitats;
- provide educational or research field areas for the long-term study of natural changes and balancing forces in undisturbed ecosystems; and,
- promote understanding and appreciation among the people of the Province of the scientific, educational and cultural values represented by the establishment of special places.

Duncans Cove

The Duncans Cove Nature Reserve was established in December 2004 (Province of Nova Scotia 2004) under the *Special Places Protection Act* and is the only nature reserve within SHACI Units 4-6. Duncans Cove is also recognized as a Site of Ecological Importance.

This undulating granite headland with sloping banks and cliffs is located between Halifax and Sambro Harbours. The Nature Reserve occupies 369 ha (Province of Nova Scotia 2004). Floral composition ranges from scattered white spruce stands near the seashore, a broom crowberry (*Corema conradii*) – reindeer moss (*Cladina* spp.) community in higher areas, sphagnum moss (*Sphagnum* spp.) – sedge (*Scirpus caspitosus*) bogs in the hollows, and scattered tamarack (*Larix larcina*) and black spruce (*Picea mariana*) individuals further inland. Duncans Cove is an excellent representative of a coastal headland, barren and bog ecosystem, and hosts several rare plants, including the Arctic blueberry (*Vaccinium uligonosum*), Curly-grass fern (*Schizaea pusilla*) and Bog orchids (e.g., *Cladina terrae-novae*) (CCIBPCTCS 1974, Province of Nova Scotia 2004). This area receives heavy, unmanaged use, including that of all-terrain vehicles, which has degraded and currently threatens the area (EAC 1999, MacKinnon pers. comm. 2003).

Shubenacadie Canal

The Shubenacadie Canal is the most significant 19th century canal development project in the Maritimes and, as such, has been declared a designated Special Place under Nova Scotia's *Special Places Protection Act*. It was constructed through the Shubenacadie waterway, a system of 115 rivers and lakes connecting the Bay of Fundy and Halifax Harbour. This waterway was used for centuries by the Mi'kmaq people before the construction of the canal, the initial plans for which were formed in 1824 (Nova Scotia Museum 2003). The canal was operational for only 12 years beginning in 1858, its demise ultimately caused by two factors: the newly lowered railway bridge spans and the Town of Dartmouth's appropriation of a canal reservoir for drinking water.

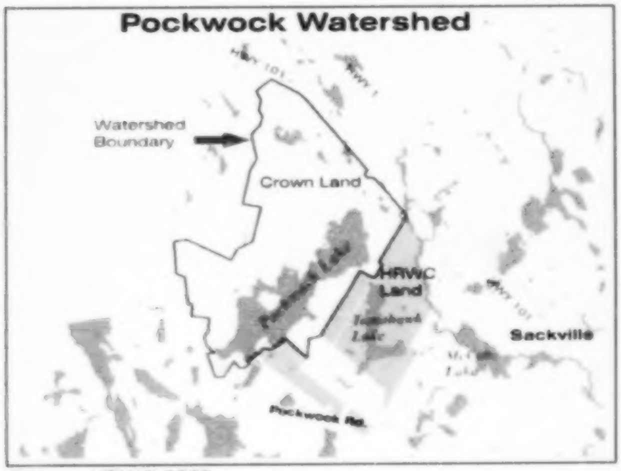
Most of the canal properties are controlled by the Shubenacadie Canal Commission, which aims to preserve the historic features of the Canal and to provide access to the canal system for the education and enjoyment of the public. The canal has also been declared a National Historic Civil Engineering Site (Nova Scotia Museum 2003).

Water supply areas

SHACI Units 4-6 is serviced by at least twelve water supply areas, including both large and small, satellite systems. Some of the large areas are designated as protected water areas under Nova Scotia's *Environment Act* (1994-95); the designations and accompanying regulations usually extend beyond the water body boundary to the surrounding watershed. These water supply areas are described below.

Pockwock Lake watershed

This lake is the main water supply for Halifax, Bedford, Sackville, Timberlea, Fall River and Waverley. The watershed is primarily owned by the provincial Crown and is a designated protected water supply area. The regulations for this watershed prohibit open fires between April and October, and restrict swimming, bathing, washing, vehicle and vessel traffic, fishing, forestry, road construction activities, and any other activities that may affect the ability of the watershed to continually provide potable water. The Halifax Region Water Commission (HRWC) jointly manages the watershed with the Nova Scotia Department of Natural Resources. The watershed encompasses approximately 5661 ha, and can safely produce a daily yield of 145 500 m^3 (HRWC 2002, HRWC 2003).



Source: HRWC 2003

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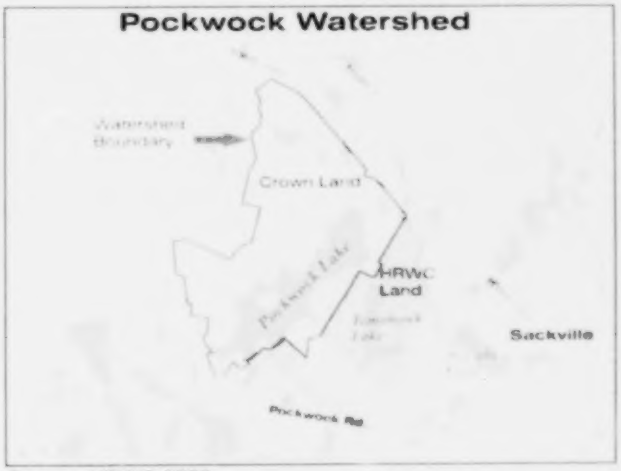

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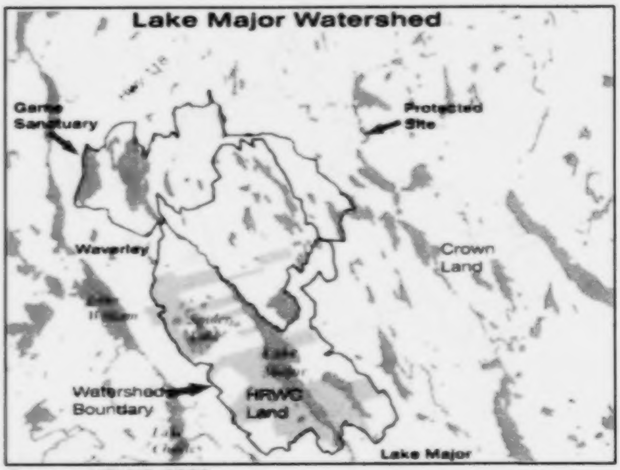
This lake is the main water supply for Halifax, Bedford, Sackville, Timberlea, Fall River and Waverley. The watershed is primarily owned by the provincial Crown and is a designated protected water supply area. The regulations for this watershed prohibit open fires between April and October, and restrict swimming, bathing, washing, vehicle and vessel traffic, fishing, forestry, road construction activities, and any other activities that may affect the ability of the watershed to continually provide potable water. The Halifax Region Water Commission (HRWC) jointly manages the watershed with the Nova Scotia Department of Natural Resources. The watershed encompasses approximately 5661 ha, and can safely produce a daily yield of 145 500 m^3 (HRWC 2002, HRWC 2003).

Lake Major watershed

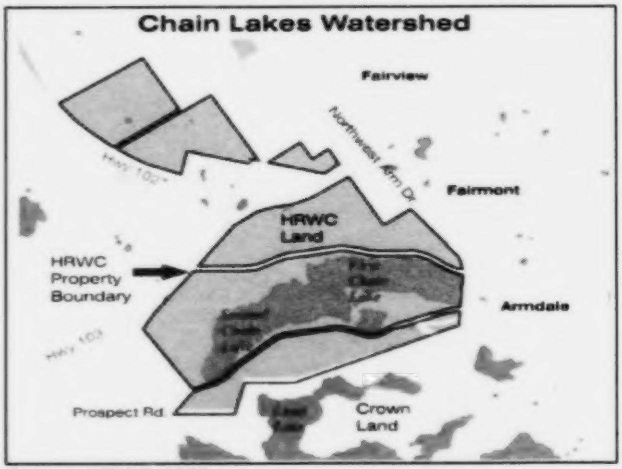
Lake Major is the water supply for Dartmouth, Cole Harbour, Westphal and Eastern Passage, and is also a designated protected area, for which accompanying regulations are similar to those of Pockwock Lake. The watershed is capable of safely producing approximately 65 900 m^3 of potable water daily, and encompasses approximately 7000 ha. Its ownership is divided among the provincial Crown, the HRWC and private individuals from three local communities, in decreasing proportions. Approximately one third of the designated watershed overlaps the Waverley-Salmon River Long Lake Wilderness Area and is protected from a variety of activities under the *Wilderness Areas Protection Act* (1998) (HRWC 2003).



Source: HRWC 2003

Chain Lakes watershed

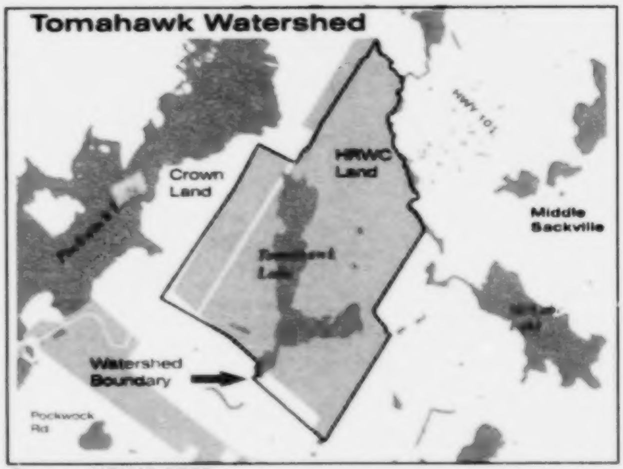
The Chain Lakes watershed is located west of Northwest Arm Drive in Halifax. It encompasses approximately 240 ha and serves as the backup water supply to Pockwock Lake (HRWC 2003).



Source: HRWC 2003

Tomahawk Lake watershed

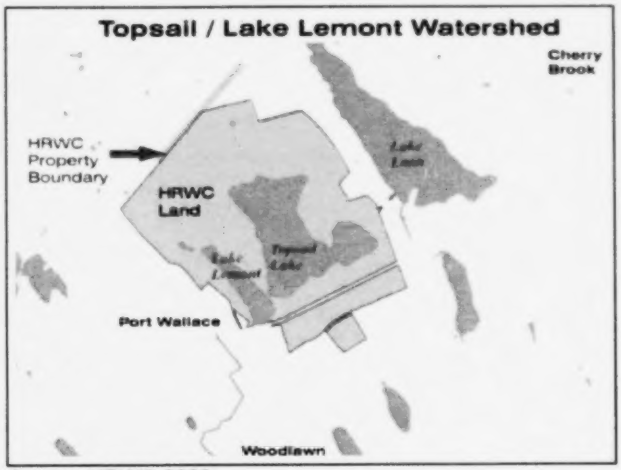
The Tomahawk Lake watershed encompasses approximately 1500 ha. It is not designated but is 90% owned and actively managed by the HRWC. This watershed is reserved as a potential future supplementary supply for the areas now served by Pockwock Lake (HRWC 2003).



Source: HRWC 2003

Topsail/Lamont watershed

The Topsail/Lamont watershed is protected by designation and is a former water supply for the Dartmouth area maintained as a backup for that area. The watershed is approximately 350 ha, and is located in the heart of Dartmouth, north of Highway 7 (HRWC 2003).



Source: HRWC 2003

Bennery Lake watershed

The Bennery Lake Watershed Protected Water Area encompasses approximately 660 ha (*Environment Act* 1944-95). Although no households draw water from this watershed, the treated water supply serves businesses in Aerotech Park, the Halifax International Airport and the adjacent commercial area (HRM 2004).

Small systems

The HRWC operates eight smaller "satellite" water supply areas in small communities that serve from 9 to 300 customers in rural communities outside the urban core (Table 21-4).

Table 21-4: Small water supply areas operated by the HRWC (compiled from HRWC 2003)

Name	Location	Water source
North Preston	Johnston Road, North Preston	Long Lake surface water
Five Island Lake	Highway #3, Five Island Lake	Groundwater
Collins Park	Highway #2, Lake Fletcher, Wellington	Lake Fletcher surface water
Middle Musquodoboit	Middle Musquodoboit	Musquodoboit River surface water
Lively Subdivision	Middle Sackville	Groundwater
Churchill Estates	Herring Cove	Groundwater
Silver Sands	Cow Bay Road	Groundwater
Miller Lake	Miller Lake Road, Fall River	Groundwater

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Beaches Act. R.S.N.S. 1989, c. 32.

BSC (Bird Studies Canada). 2003a. IBA Site Listing: Eastern Shore Islands, Nova Scotia. http://www.bsc-eoc.org/iba/site.cfm?siteID=NS027&lang=en (accessed 12 August, 2003).

BSC (Bird Studies Canada). 2003b. IBA Site Listing: Musquodoboit, Nova Scotia. http://www.bsc-eoc.org/iba/site.cfm?siteID=NS014&lang=en (accessed 12 August, 2003).

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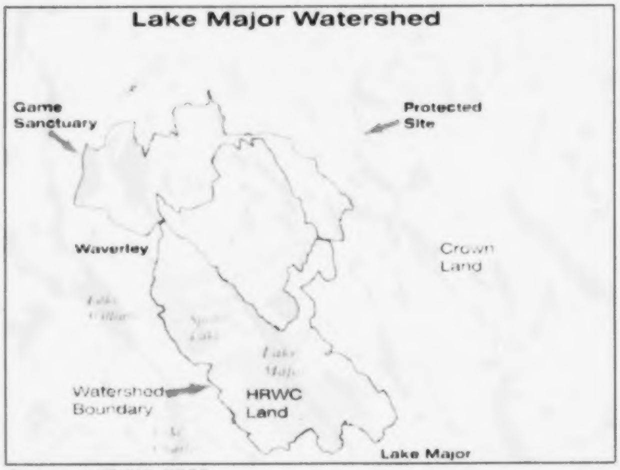
Lake Major Watershed

Source: HRWC 2003

Chain Lakes watershed

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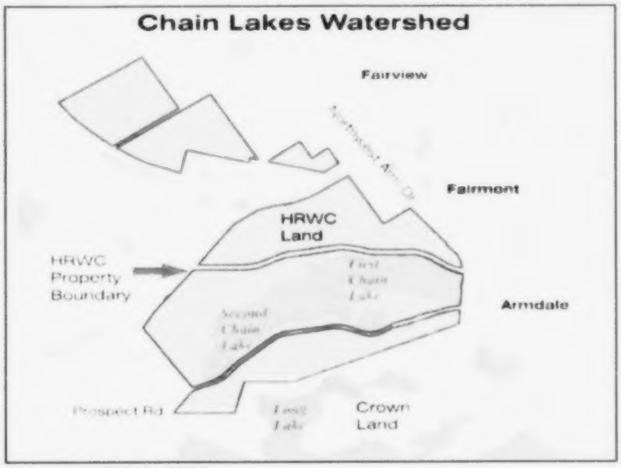
Chain Lakes Watershed

Source: HRWC 2003

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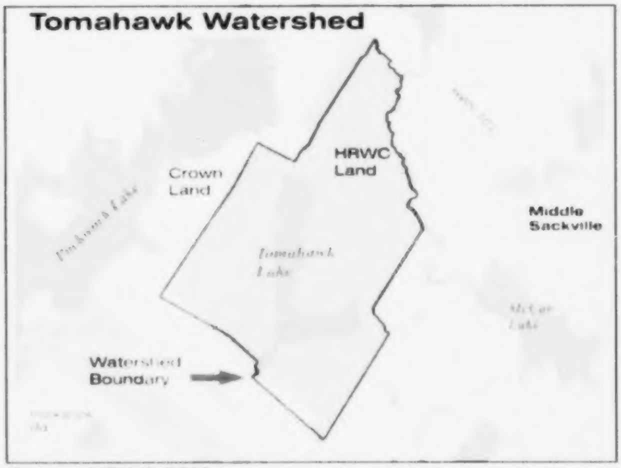
Tomahawk Watershed

Source: HRWC 2003

Topsail/Lamont watershed

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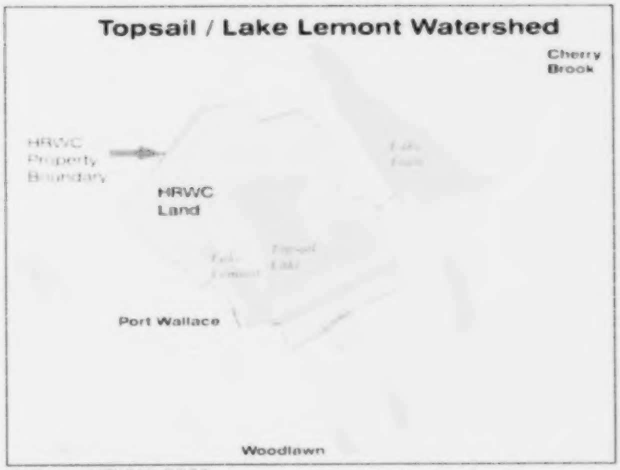

Source: HRWC 2003

Bennery Lake watershed

The Bennery Lake Watershed Protected Water Area encompasses approximately 660 ha (*Environment Act* 1944-95). Although no households draw water from this watershed, the treated water supply serves businesses in Aerotech Park, the Halifax International Airport and the adjacent commercial area (HRM 2004).

Small systems

The HRWC operates eight smaller "satellite" water supply areas in small communities that serve from 9 to 300 customers in rural communities outside the urban core (Table 21-4).

Table 21-4: Small water supply areas operated by the HRWC (compiled from HRWC 2003)

Name	Location	Water source
North Preston	Johnston Road, North Preston	Long Lake surface water
Five Island Lake	Highway #3, Five Island Lake	Groundwater
Collins Park	Highway #2, Lake Fletcher, Wellington	Lake Fletcher surface water
Middle Musquodoboit	Middle Musquodoboit	Musquodoboit River surface water
Lively Subdivision	Middle Sackville	Groundwater
Churchill Estates	Herring Cove	Groundwater
Silver Sands	Cow Bay Road	Groundwater
Miller Lake	Miller Lake Road, Fall River	Groundwater

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22 - Restricted water use

In addition to the Restricted and Limited Land Use Areas in SHACI Units 4-6, there are restricted areas in coastal waters. This section focuses on the areas which are primarily restricted to certain fisheries due to bacterial/biotoxin contamination or for management and conservation purposes.

Shellfish closure areas

The primary objective of the Canadian Shellfish Sanitation Program (CSSP) is to protect the public from consuming contaminated shellfish by controlling the harvesting of shellfish in Canada (Environment Canada 2004). The Program is administered by the Department of Fisheries and Oceans (DFO), Canadian Food Inspection Agency (CFIA) and Environment Canada. The *Fisheries Act* (1985), Management of Contaminated Fisheries Regulations, the *Fish Inspection Act* (1985), and Fish Inspection Regulations provide the legal authority for the CSSP. These acts and regulations enable the departments to classify all shellfish growing areas according to their suitability for shellfish harvesting on the basis of sanitary quality and public health safety. This authority also permits the DFO and CFIA to, among other things, restrict harvesting of shellfish from actual and potentially affected areas in a public health emergency and control shellfish harvesting from closed areas.

Under the authority of the *Fisheries Act* and Regulations, DFO enforces closure regulations and enacts the opening and closing of shellfish growing areas (*Fisheries Act* 1985). Environment Canada is responsible for classifying shellfish growing areas based on sanitary and bacteriological water quality surveys of the area. An area will be closed to direct harvesting due to chemical or bacteriological contamination. Although shellfish harvesting is prohibited from closed areas for direct marketing, this does not imply that the area is necessarily "polluted" or that these shellfish cannot be utilized commercially. Contaminated shellfish can purify themselves if placed in clean waters for a certain period of time under suitable conditions. This is not the case, however, for shellfish contaminated with paralytic shellfish poisoning or chemical toxins. Shellfish from a closed area can be used only by permit under specified conditions for depuration, relaying, experimental purposes or other approved processing to make it safe for human consumption (CSSP 1992).

In 2004, shellfish areas in Atlantic Canada were classified as: approved (4185 km^2), conditional (80 km^2) and closed (2152 km^2) (Environment Canada 2004). More than 2000 km^2 of coastal waters in Atlantic Canada (33% of the total classified shellfish growing area) have been closed to shellfish harvesting. Classified Growing Areas are regularly surveyed to ascertain their suitability for the harvesting of shellfish according to accepted water quality standards and general sanitary conditions in the growing area.

There are currently 48 Environment Canada recommended closures within SHACI Units 4-6, totalling 147.79 km^2 (Table 22-1). Environment Canada has recommended that DFO establish these shellfish closures based on existing shoreline sanitary conditions and the observed marine water quality (Craig pers. comm. 2005). Maps for the shellfish closure areas in Table 22-1 are found at http://www.ns.ec.gc.ca/epb/sfish/maps/ns/ns.html. Please note that these maps are updated biannually and may be superseded by the DFO's Regulations (Environment Canada 2003). Thus for the most up-to-date information the nearest DFO office should be contacted.

Table 22-1: Closed shellfish harvesting areas within SHACI Units 4-6

Locator	Location	Area (km^2)
NS-11-040-002	Liscomb Harbour	2.51
NS-11-040-003	Hawbolt Cove/Marie Joseph	0.34
NS-11-040-004	Ecum Secum Harbour	1.44
NS-11-040-005	Necum Teuch Bay/Moser River	0.41
NS-11-040-006	Quoddy Harbour/Gammons Creek	0.09
NS-11-040-006	Quoddy Harbour/MacDonalds Cove	0.08
NS-11-040-007	Beaver Harbour/Port Dufferin	0.31
NS-11-050-001	Sheet Harbour	6.96
NS-11-050-001	Sheet Harbour/Sheet Harbour Passage	0.37
NS-11-050-002	Mushaboom Harbour	1.51
NS-11-060-002	Popes Harbour	0.44
NS-11-060-003	Shoal Cove-Glawsons Cove	0.15
NS-11-060-003	Tangier Harbour/Webbs Cove	0.93
NS-11-060-003	Shoal Bay/Sand Cove	0.02
NS-11-060-004	Southwest Cove	0.26
NS-11-060-005	Clam Bay	0.24
NS-11-060-005	Clam Harbour	0.53
NS-11-060-005	Clam Harbour/Unnamed Cove	0.61
NS-11-060-005	Clam Harbour	0.10
NS-11-060-006	Jeddore Harbour/Eastern Arm	2.41
NS-11-060-006	Jeddore Harbour/Western Arm	1.06
NS-11-060-006	Jeddore Harbour	2.97
NS-12-010-001	Oyster Pond	0.39
NS-12-010-001	Musquodoboit Harbour	1.96
NS-12-010-002	Petpeswick Inlet	1.26
NS-12-010-003	Chezzetcook Inlet	4.03
NS-12-010-004	Three Fathom Harbour/Rudeys head	0.28
NS-12-010-004	Three Fathom Harbour	0.05
NS-12-010-005	Lawrencetown Channel	0.11
NS-12-010-006	Cole Harbour/East Side	1.94
NS-12-010-006	Cole Harbour/West Side	1.87
NS-12-020-001	Cow Bay Lake	1.04
NS-12-020-002	Halifax Harbour	92.24
NS-13-010-002	Sambro Harbour/Sambro Basin	0.08
NS-13-010-002	Sambro Harbour/Indian Harbour	0.16
NS-13-010-003	Pennant Bay/Terence Bay	1.19
NS-13-010-005	Prospect Bay	0.22
NS-13-010-006	Shad Bay	0.64
NS-13-010-008	Port Dover	0.87
NS-13-020-001	St. Margarets Bay/Indian Harbour	0.17
NS-13-020-001	St. Margarets Bay/Woodens, Long, Mosers Coves	0.73
NS-13-020-001	St. Margarets Bay/Hubley & MacDonalds Coves	0.28
NS-13-020-001	St. Margarets Bay/Frostfish Cove	0.34
NS-13-020-001	St. Margarets Bay/Boutiliers Cove	0.11
NS-13-020-001	St. Margarets Bay/Hacketts Cove	0.21
NS-13-020-002	St. Margarets Bay/Rye Hill Cove	11.15
NS-13-020-002	St. Margarets Bay/Hubbards Cove	1.36
NS-13-020-003	St. Margarets Bay/Mill Cove	1.38

Several coastal communities in New Brunswick, PEI and Nova Scotia have begun remediation and shellfish restoration activities. These activities have been successful in re-opening 2485 ha of shellfish closures for commercial shellfish harvesting (Environment Canada 2004).

Fisheries closures

In addition to the sanitary and bacteriological water quality closures recommended by Environment Canada, DFO may have additional closures in place due to natural biotoxin levels, elevated bacterial levels in shellfish meats, as well as management and conservation purposes. DFO may also implement emergency closures due to oil spills and vessel sinkage. Table 22-2 lists the fisheries closures in place in SHACI Units 4-6 as of January 2005, based on Variation Orders. Note that these closures do not include those specified in fisheries management plans (e.g., restricted fishing seasons). For the most up-to-date information regarding fisheries closures, contact the nearest DFO office.

Table 22-2: Fisheries closures in SHACI Units 4-6*

Affected area	Species	Closure details	Effective date	End date	Variation order
Salmon Fishing Areas 19 to 23; includes all of Units 4-6 (Figure 22-1)	Salmon	Closed to commercial fishing by any gear other than angling	May 15/97	Open ended	1997-077
Herring Fishing area 20; includes all of Units 4 and 5, and part of Unit 6 (Figure 22-2)	Herring	Embayment lines are closed to mobile gear fishing	Jan. 9/98	Open ended	1998-025
Herring Fishing area 20; includes all of Units 4 and 5, and part of Unit 6 (Figure 22-2)	Herring	An area 25 miles seaward from the established Embayment Closure Line is closed to mobile gear fishing	Jan. 9/98	Open ended	1998-027
Herring Fishing Areas 17-22 and Mackerel Fishing Areas 17-22; includes all of Units 4-6 (Figure 22-2)	Mackerel, herring	Closed to monofilament gill net gear from May 1 to July 15	May 1/01	Open ended	2001-069
A portion of east Chezzetcook Inlet (Unit 5) (Figure 22-3)	Bar clam, bay quahog, razor clam, soft-shell clam	Closed to harvesting by any gear; scientific closure	Jan. 5/02	Open ended	2002-017
All of the tidal waters adjacent to the county of Shelburne, Queens, Lunenburg and Halifax (West of Pennant Point), known as Clam Harvesting Area 4 (Figure 22-4)	Soft-shell clam, razor clam, bay quahog, bar clams	Closed to harvesting by any gear from January 1 to March 31	Dec. 23/04	Dec. 31/06	2003-178
NAFO Divisions 4VWX and 5; includes all of SHACI Units 4-6 (Figure 22-5)	Halibut	Closed to fishing by means of Class C1 to C 3000 from October 20, 2004 to March 31, 2005	Oct. 20/04	Mar. 31/05	2004-099
NAFO Divisions 4VWX and 5; includes all of SHACI Units 4-6 (Figure 22-5)	Groundfish	Closed to fishing by means of Class C1017 from November 3, 2004 to March 31, 2005	Nov. 3/04	Mar. 31/05	2004-101
Lobster Fishing Area 33; includes SHACI Unit 4 and Unit 5, west of Cole Harbour (Figure 22-6)	Lobster	Closed to fishing from June 1 to 07:00 h on November 30	Nov. 28/04	Open ended	2004-105
Tidal and inland waters of Nova Scotia except for Waters that flow into Jeddore Harbour and Musquodoboit Harbour	Smelt	Closed to fishing by dip nets from June 16 to March 31 and from 00:01 h each Friday to 24:00 h on the following Sunday every week Closed to fishing by dip nets and spears from January 1 to December 31	April 10/02	Open ended	2002-058

Table 22-2: Fisheries closures in SHACI Units 4-6 cont'd

Affected area	Species	Closure details	Effective date	End date	Variation order
Tidal and inland waters of SHACI Unit 5 from east of Pennant Point and Unit 6 (excluding Conrods Head to Collies Head)	Bay quahog, Razor clam, Soft-shell clam, Bar clams	Closed to fishing by any gear from January 1 to March 31	Dec. 27/04	Mar. 31/05	2004-108
Cole Harbour at Pensey Head to Conrods Head	Bay quahog, Razor clam, Soft-shell clam, Bar clams	Closed to fishing by any gear from December 1 to February 28	Dec. 27/04	Mar. 31/05	2004-108
Albro Lake, Fish Lake, Morris Lake, Russell Lake and Kinsac Lake	Trout	Closed to fishing from April 1 to December 31	Jan. 1/05	Mar. 31/05	2005-002
Albro Lake	White perch, yellow perch	Closed to fishing from April 1 to December 31	Jan. 1/05	Mar. 31/05	2005-004, 2005-006
Fish Lake, Morris Lake, Russell Lake, Kinsac Lake.	Chain pickerel	Closed to fishing from April 1 to December 31	Jan. 1/05	Mar. 31/05	2005-008

* Closures are described in relation to SHACI Units 4-6 only; for other affected areas and restrictions, please refer to the individual variation orders. Note that these closures do not include those specified (e.g., restricted fishing seasons) in fisheries management plans. For the most up-to-date information contact the nearest DFO office.

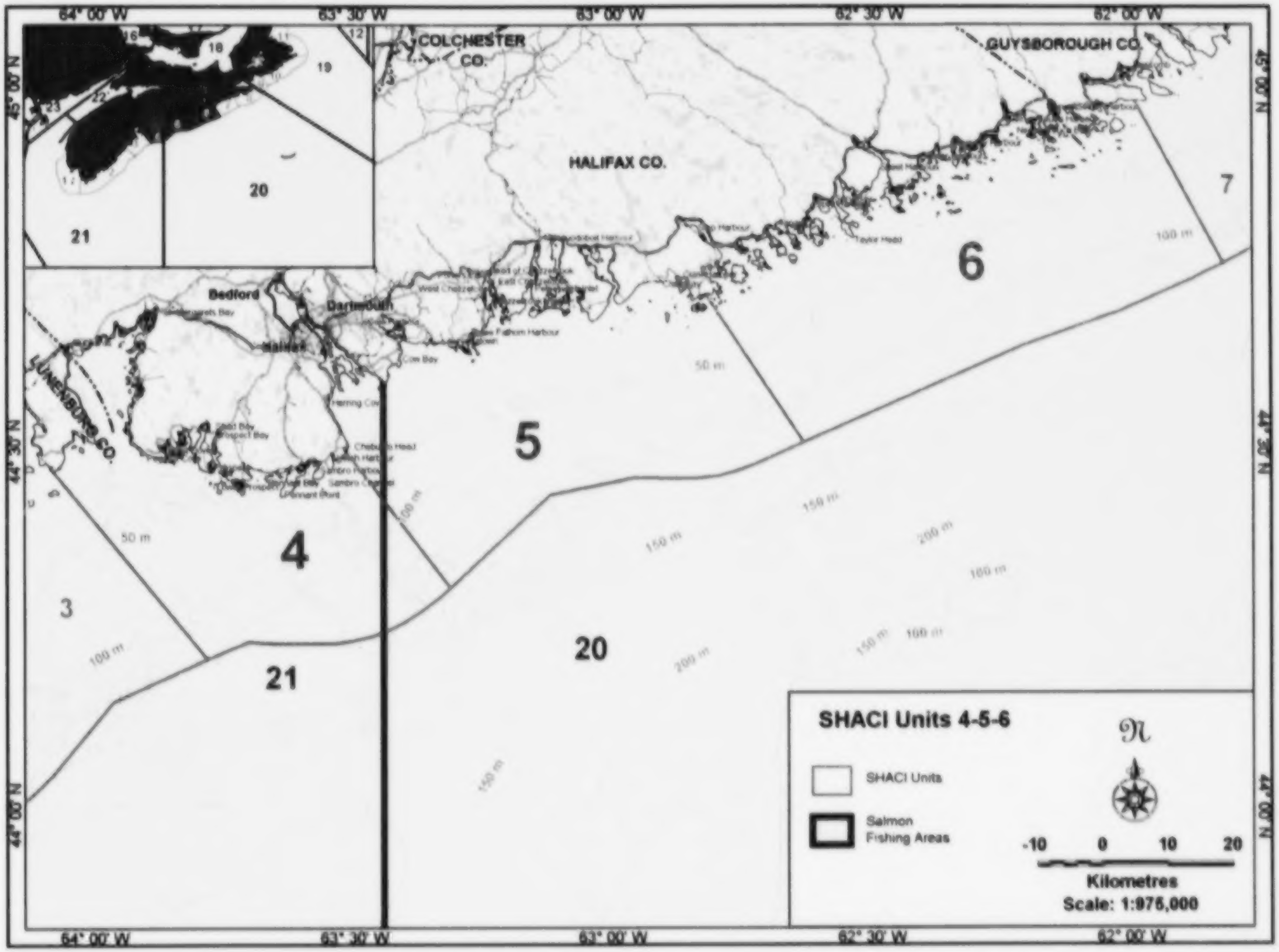

Figure 22-1: Salmon Fishing Areas (SFAs) 19 to 23 are closed to commercial salmon fishing by any gear other than angling (DFO). Basemap layers (NSGC).

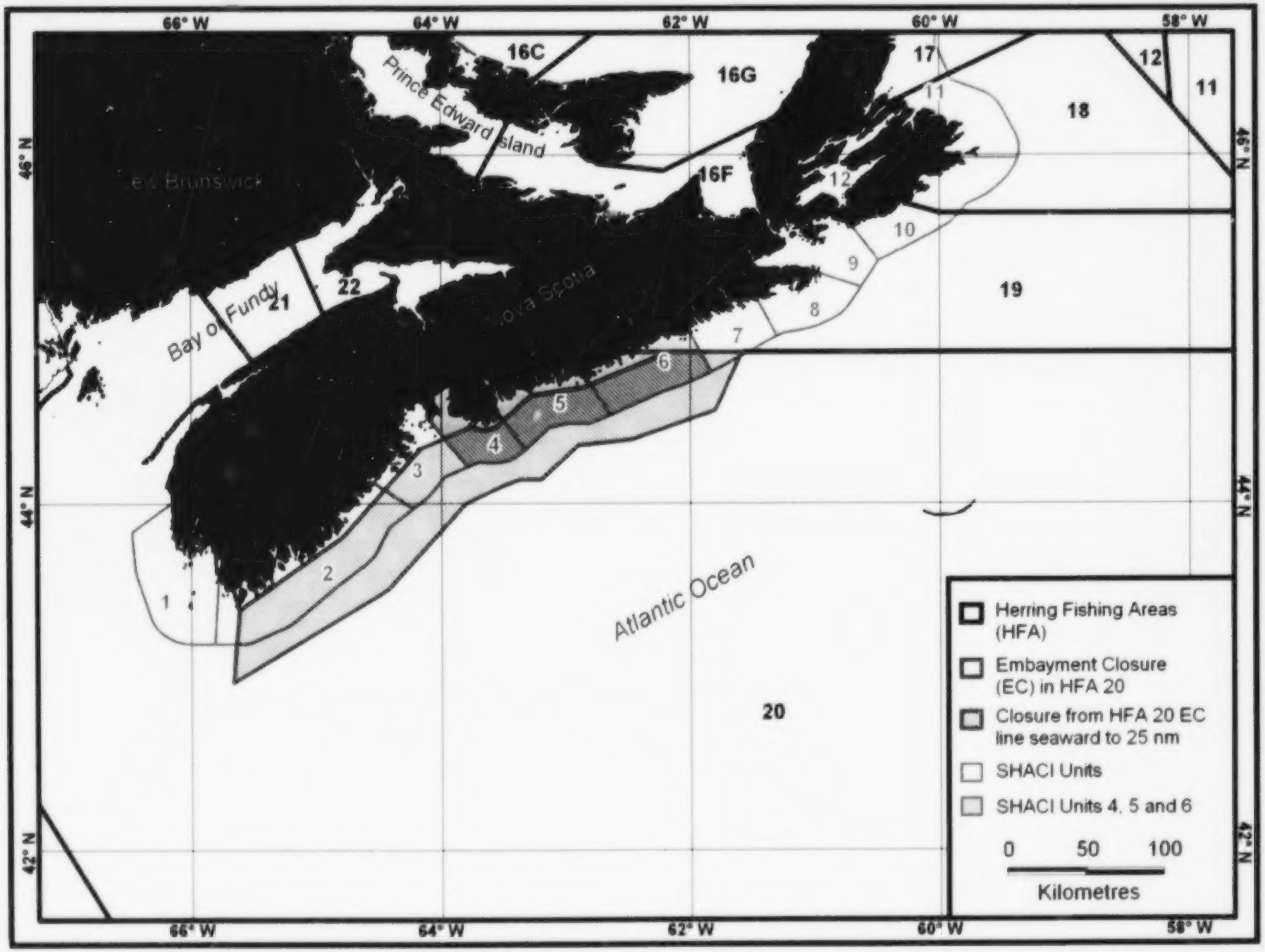

Figure 22-2: Herring Fishing Area 20 closures to mobile gear fishing for herring (DFO). Basemap layers (NRCan).

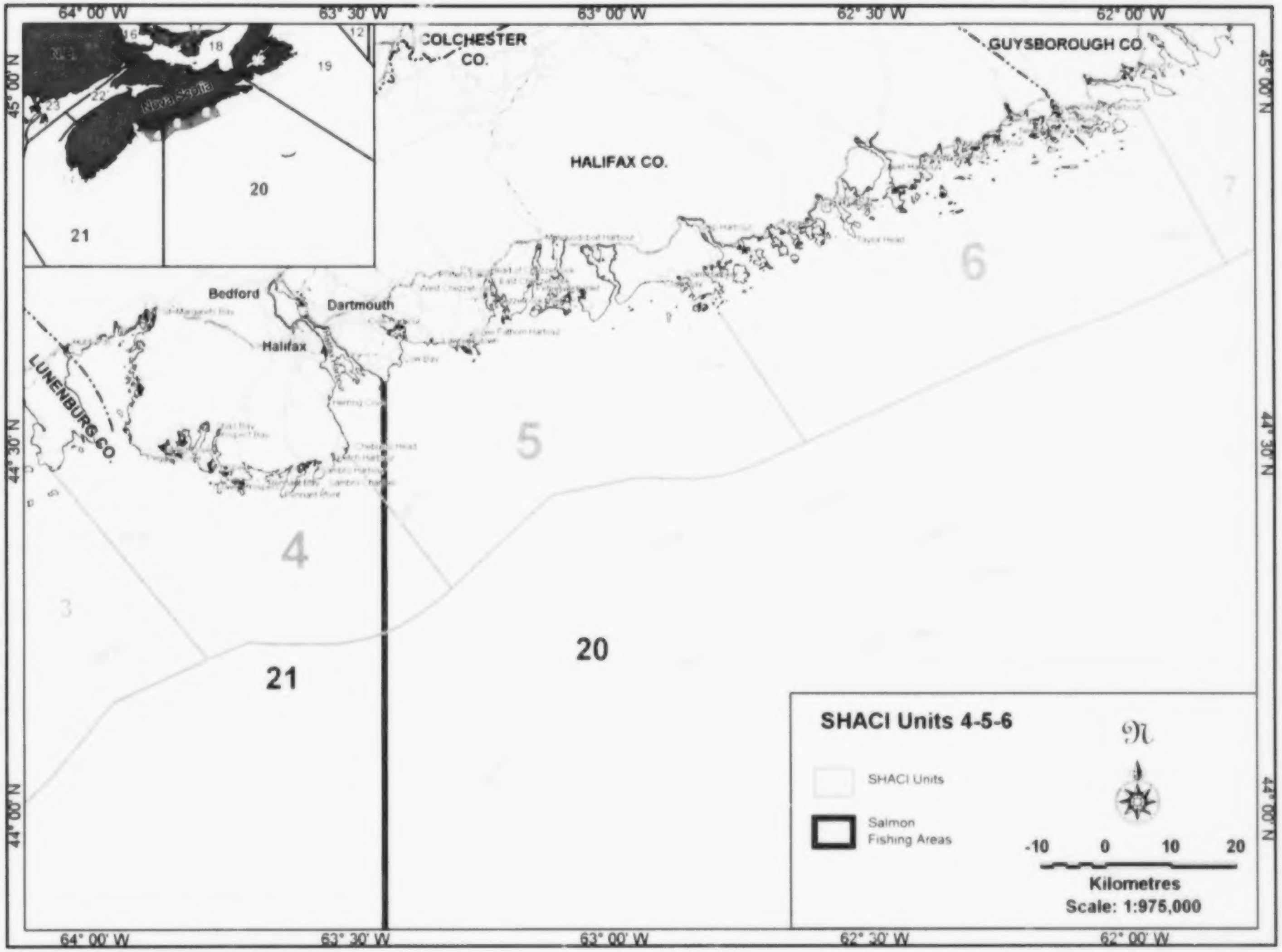

Figure 22-1: Salmon Fishing Areas (SFAs) 19 to 23 are closed to commercial salmon fishing by any gear other than angling (DFO). Basemap layers (NSGC).

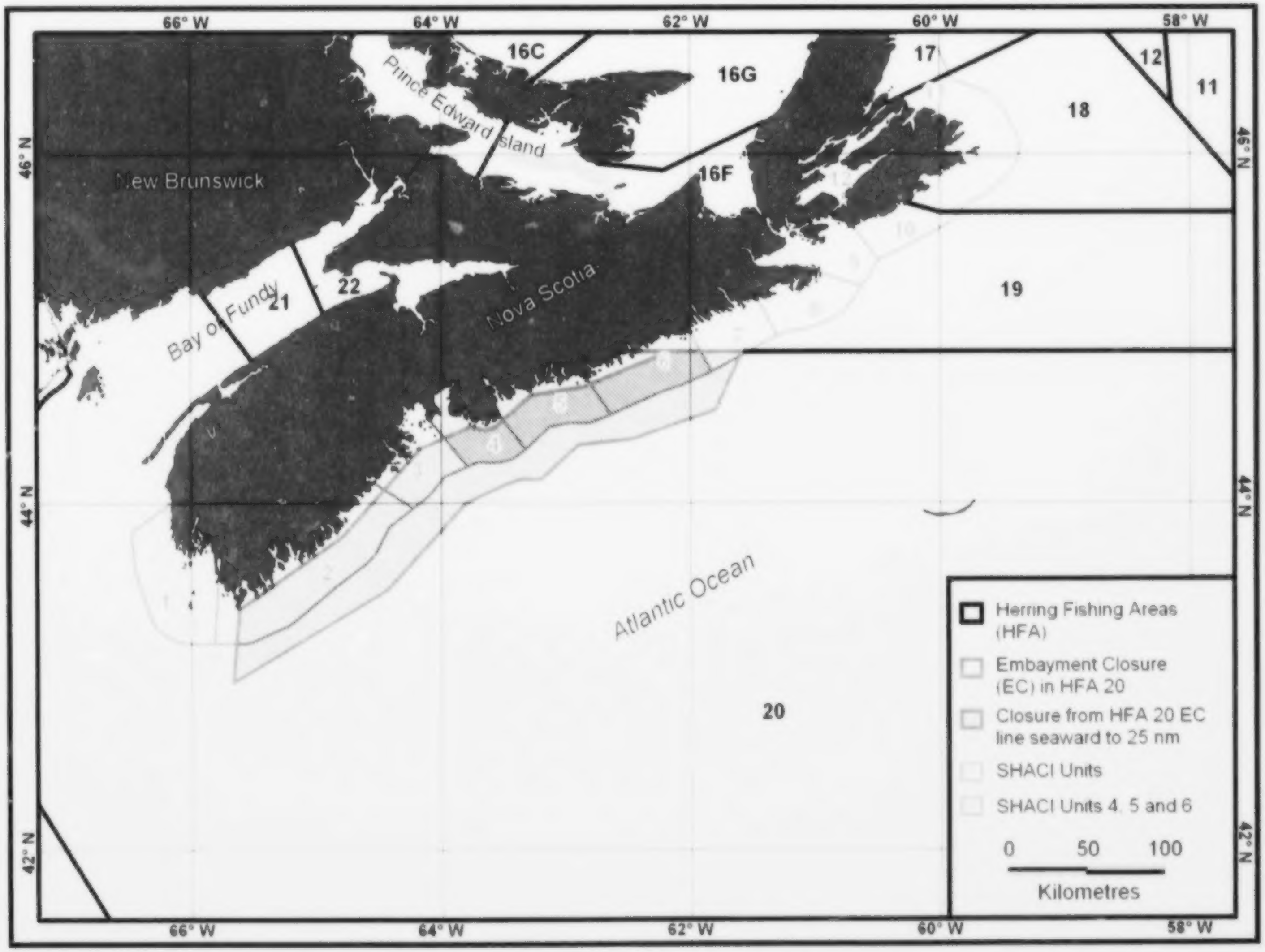

Figure 22-2: Herring Fishing Area 20 closures to mobile gear fishing for herring (DFO). Basemap layers (NRCan).

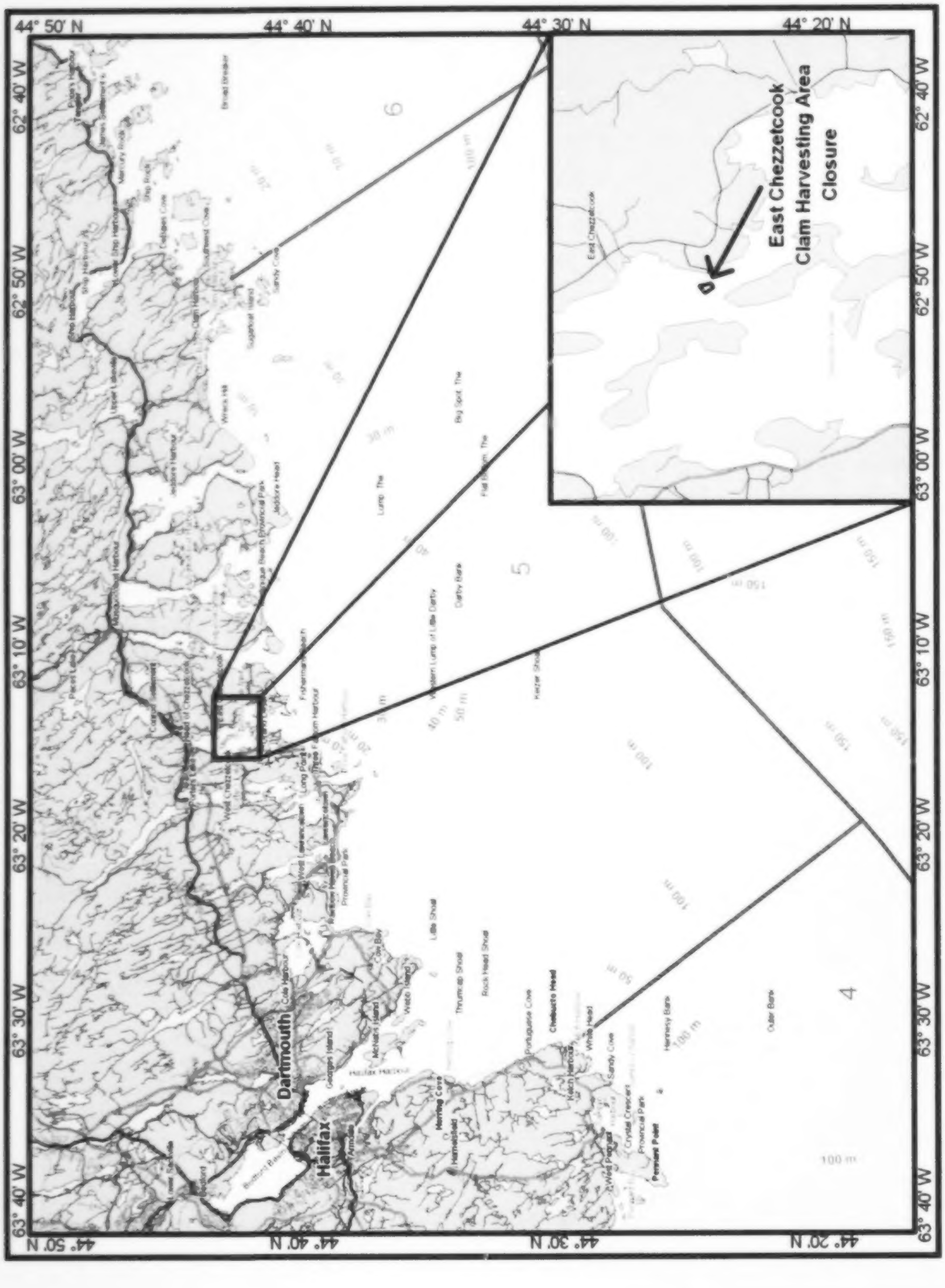

Figure 22-3: Clam harvesting area closure in East Chezzetcook. Basemap layers (NSGC).

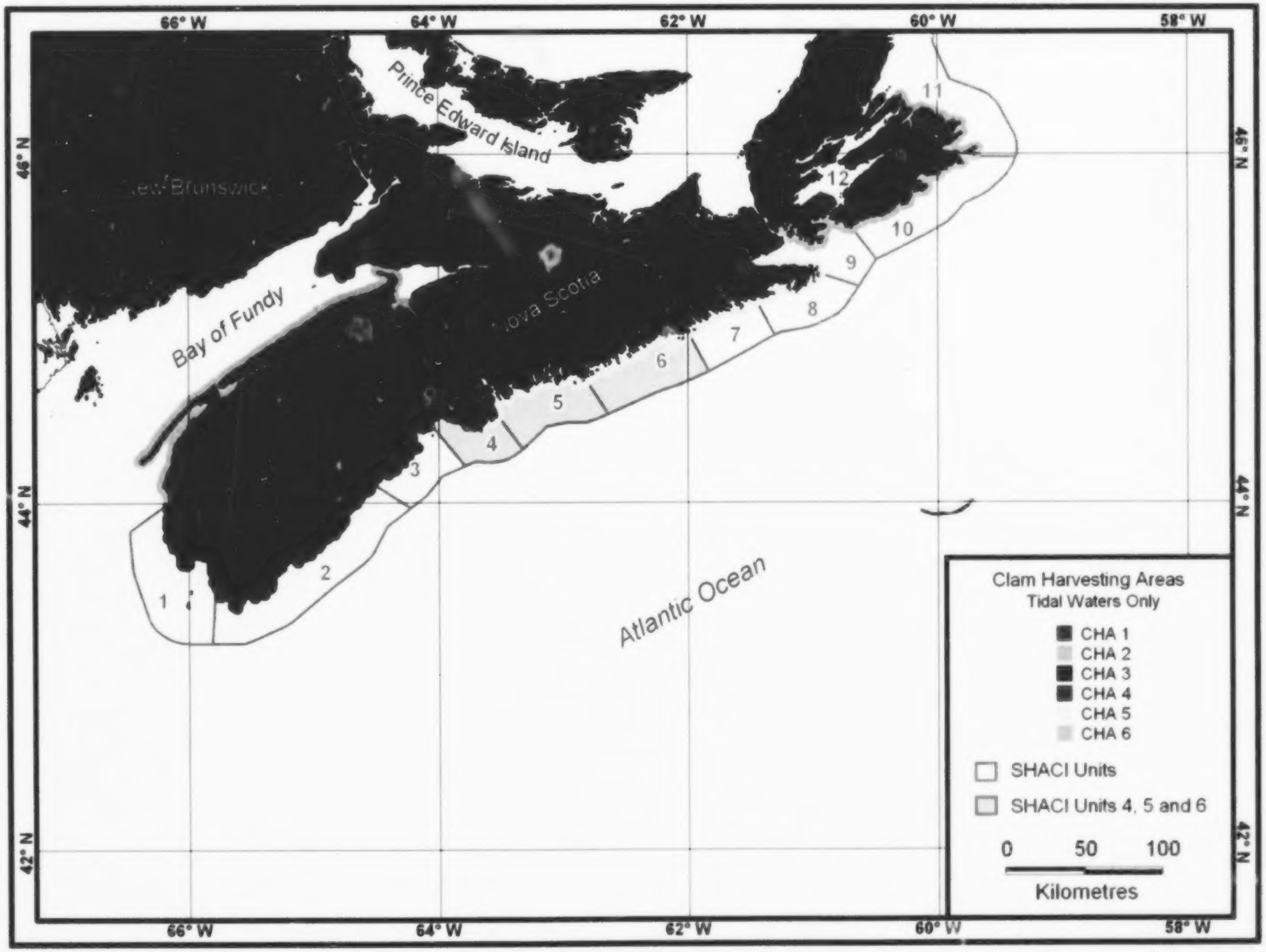

Figure 22-4: Clam Harvesting Area 4 closure of tidal waters to clam harvesting from January 1 to March 31 (DFO). Basemap layers (NRCan). *Note: The extent of the Clam Harvesting Area tidal waters do not represent the actual seaward extent of tidal waters along the coast of Nova Scotia; tidal waters shown here are for illustrative purposes only.*

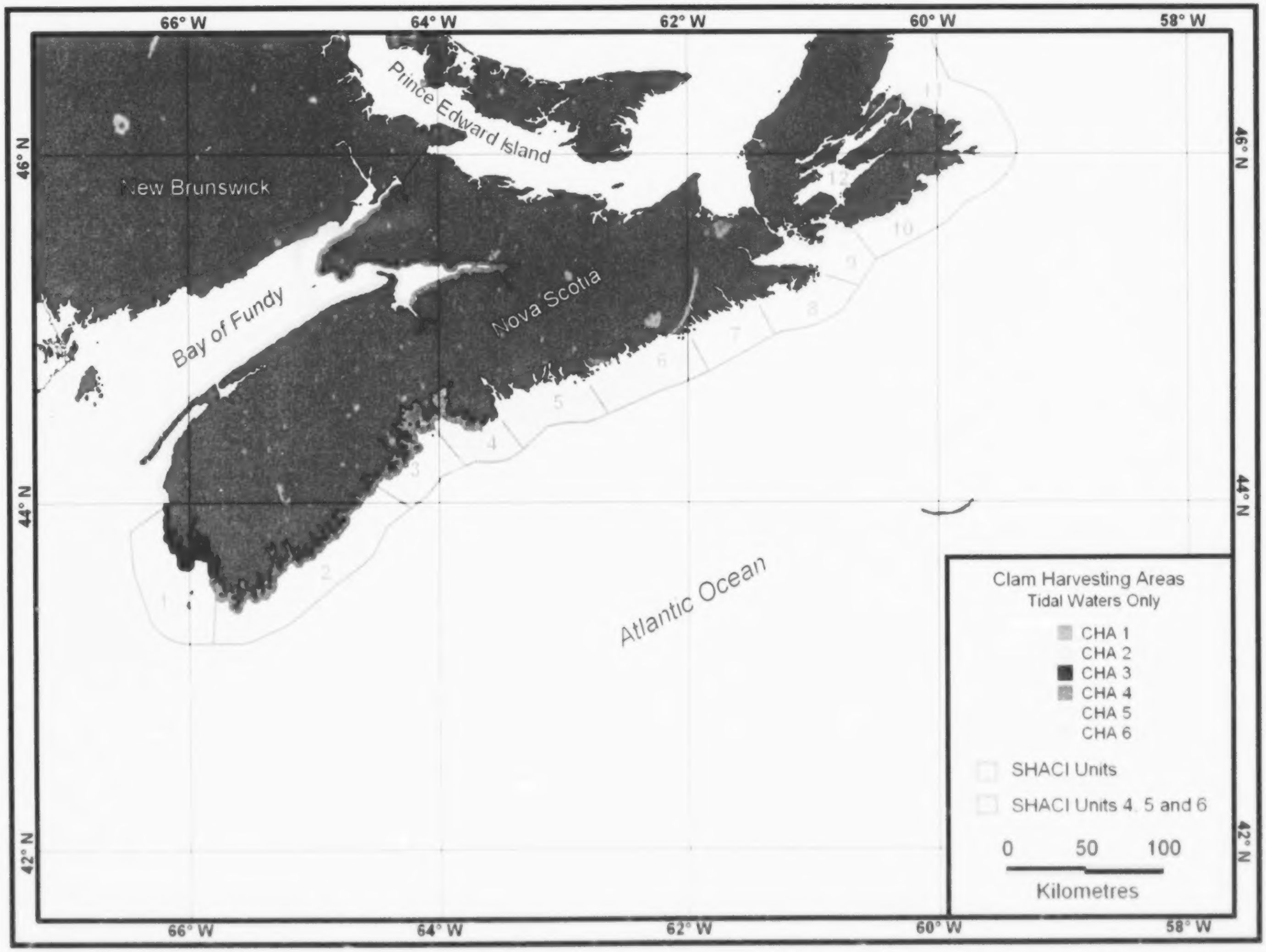

Figure 22-4: Clam Harvesting Area 4 closure of tidal waters to clam harvesting from January 1 to March 31 (DFO). Basemap layers (NRCan). *Note: The extent of the Clam Harvesting Area tidal waters do not represent the actual seaward extent of tidal waters along the coast of Nova Scotia, tidal waters shown here are for illustrative purposes only.*

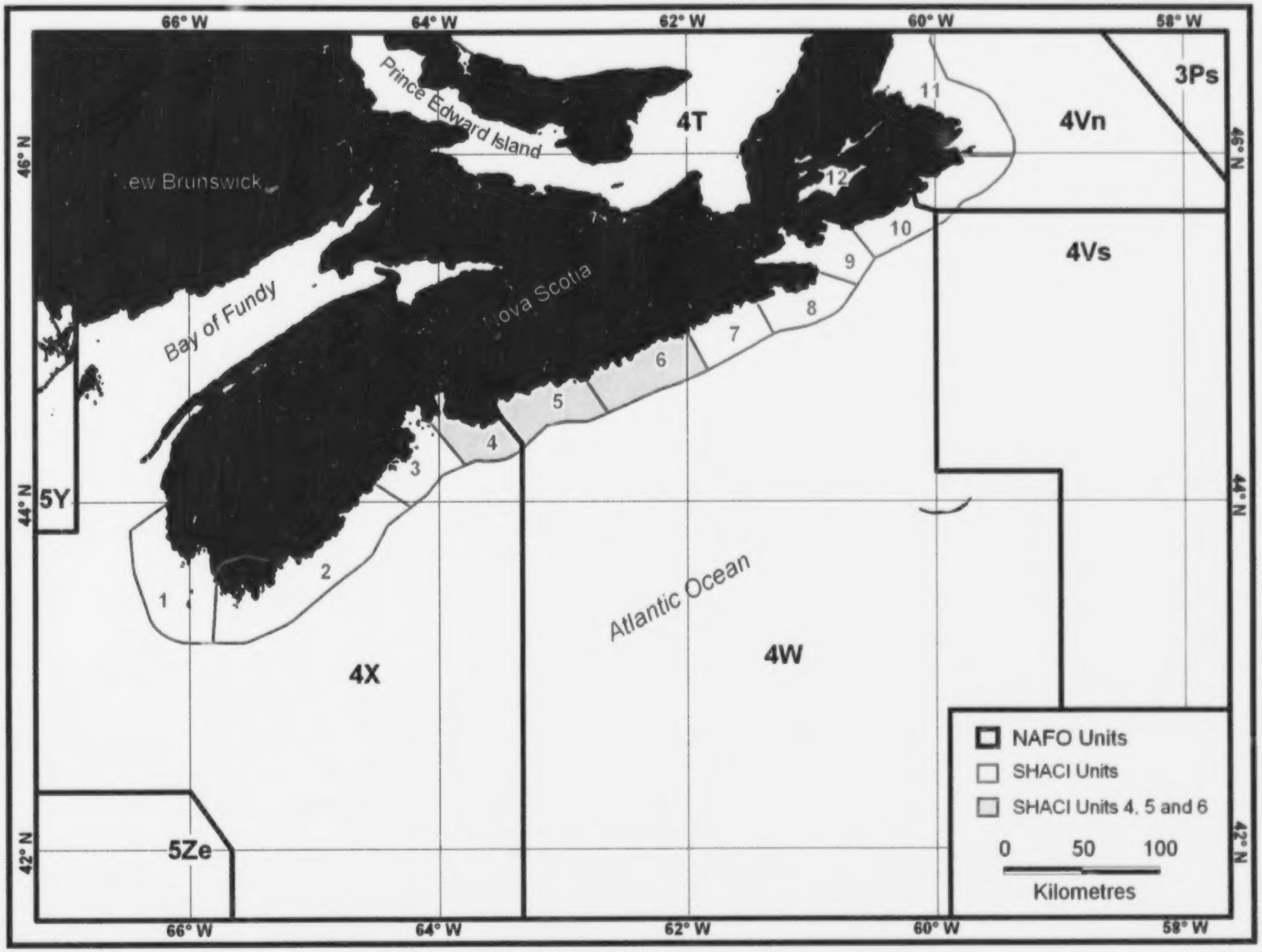

Figure 22-5: NAFO Divisions 4VWX and 5 are closed to fishing by means of Class C1-C3000 for halibut and Class C1017 for groundfish until March 31, 2005. Basemap layers (NRCan).

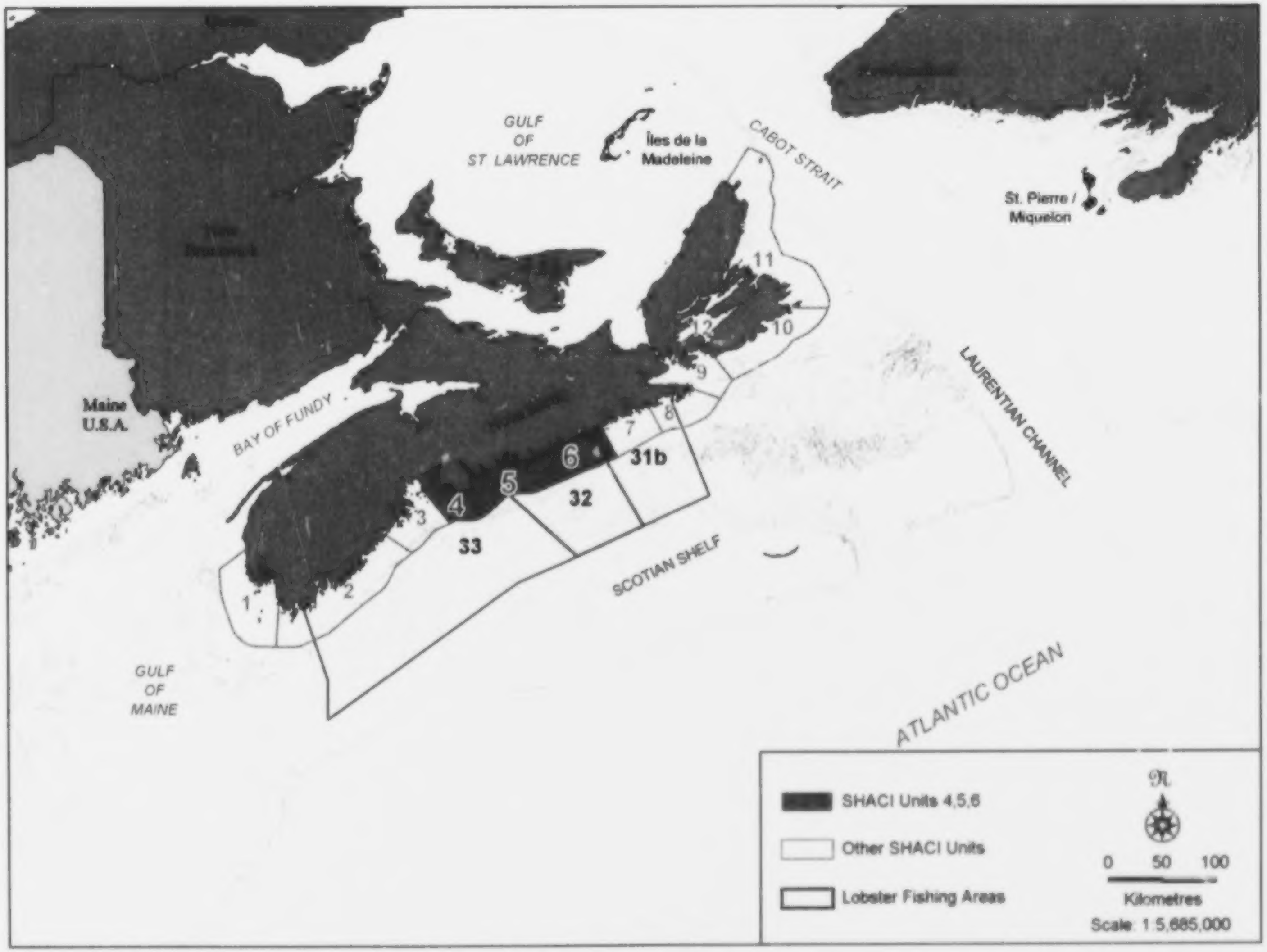

Figure 22-6: Lobster fishing area (LFA) 33 is closed to lobster fishing from June 1 to November 30 (DFO). Basemap layers (NRCan).

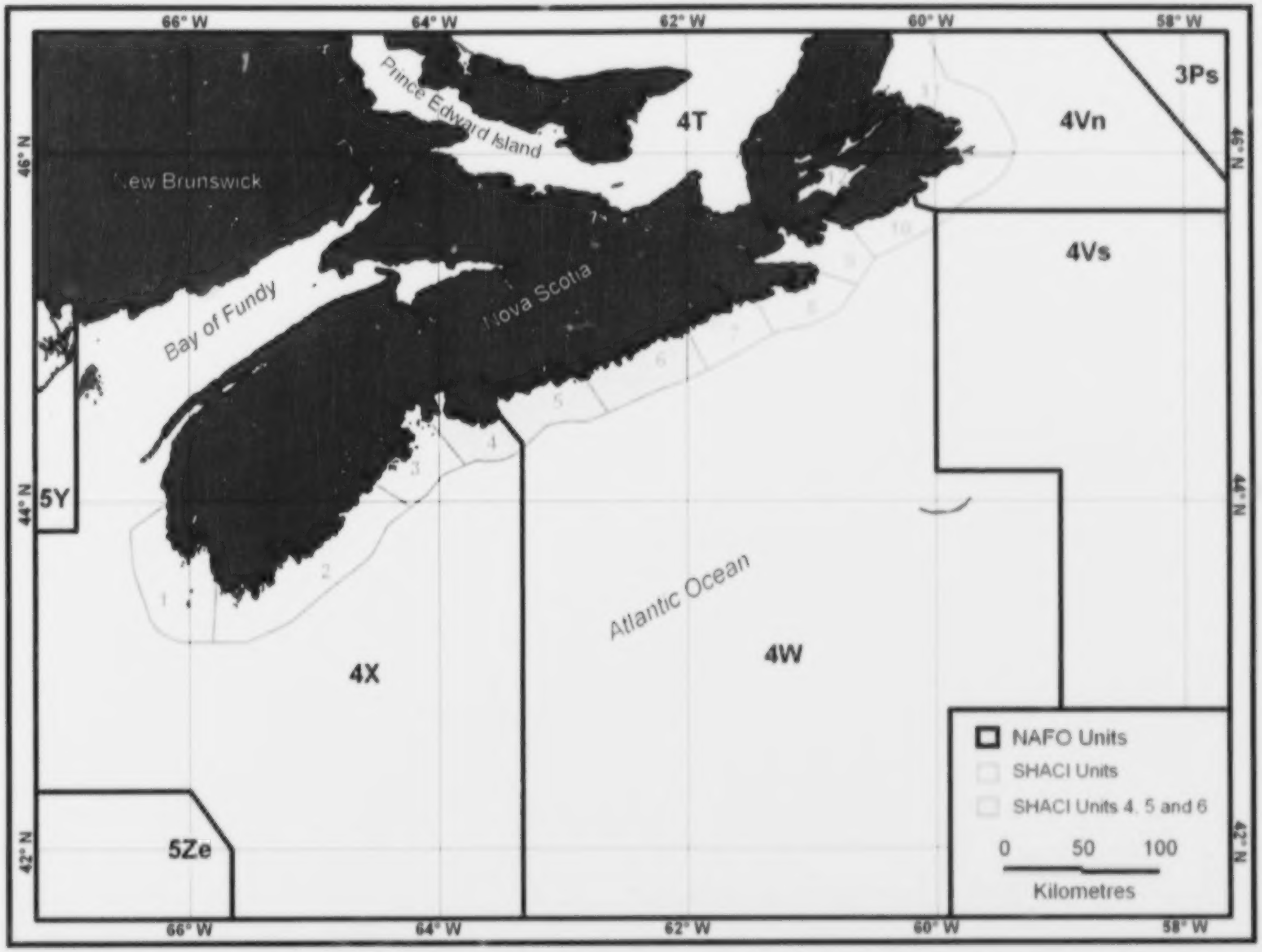

Figure 22-5: NAFO Divisions 4VWX and 5 are closed to fishing by means of Class C1-C3000 for halibut and Class C1017 for groundfish until March 31, 2005. Basemap layers (NRCan).

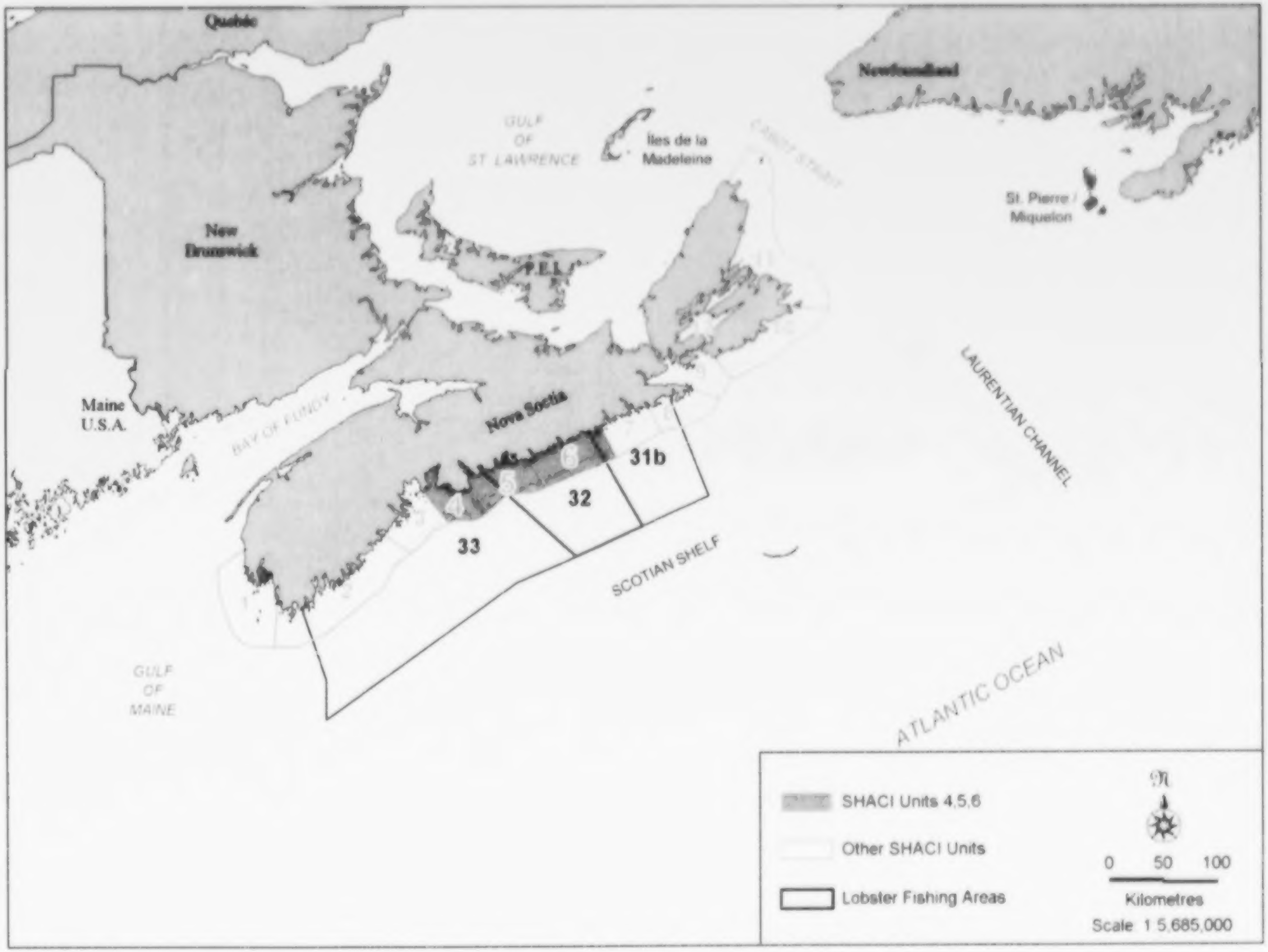

Figure 22-6: Lobster fishing area (LFA) 33 is closed to lobster fishing from June 1 to November 30 (DFO). Basemap layers (NRCan).

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Significant habitats

23 - Significant habitats

As outlined in the SHACI introduction and overview section, the purpose of this document is to identify significant coastal habitats in SHACI Units 4-6. Up to this point, the various coastal environments, species and industries have been identified and, where appropriate, important attributes and habitats have been mapped. This section attempts to synthesize this information by gathering key attributes from areas within SHACI Units 4-6 and using them to identify significant coastal habitats.

In general, SHACI Units 4-6 contain a variety of habitats that appeal to various organisms (Table 23-1 and 23-2). Specific areas within SHACI Units 4-6 and their associated attributes are given in Table 23-3. These features/attributes provide important information to help identify significant habitats. Criteria used in identifying areas as significant habitats are outlined in the SHACI introduction and overview section and include ecological attributes such as important habitat for species at risk and high productivity or biodiversity areas, and cultural and recreational attributes.

Table 23-1: General features of significance of SHACI Units 4-6

Attribute	Reference(s)
• Part of the migration pathway taken by humpback (*Megaptera novaeangliae*) and blue whales (*Balaenoptera musculus*) (endangered species) during June or early July through October to the Gulf of St. Lawrence or points further north	Conway pers. comm. 2003
• Several marine mammal species forage, calve and use the area for other, as yet-unidentified, reasons	Gowans pers. comm. 2001, Whitehead pers. comm. 2001
• Relatively large numbers of Atlantic wolffish (species of special concern) occur close to shore in the late summer and fall in certain areas	DFO 2002a
• Numerous herring spawning beds reported and extensive distribution of herring larvae along the coast	Sameoto 1971
• With the exception of soft bottom areas, the vast majority of coast could be considered lobster habitat	GCCRMP 1994, HCESCRMP 1996, HRMWWRCRMP 1996, LCCRMP 1996, Miller pers. comm. 2003
• Juvenile cod (species of special concern) are found throughout the coastal areas in SHACI Units 4-6	Clark pers. comm. 2005
• Contains breeding, migration stopover, and overwintering areas for many seabirds, shorebirds and waterfowl	

Table 23-2: General areas and attributes of significance in SHACI Units 4-6

Location	Attribute	Reference(s)
Burnt Island to Cuckold Island	• Extensive marine flats	NSDNR 2002
Chebucto Peninsula	• Significant marine plant area with continuous intertidal rocky bottom suitable as seaweed habitat that extends to greater depths than in most areas along the coast	Chapman pers. comm. 2001, Scheibling pers. comm. 2001
Cole Harbour to Musquodoboit	• Former herring spawning areas	Trippel 2002
between East Head and Taylor Head	• Juvenile haddock area (was once more extensive)	Trippel 2002
Eastern Shore	• Despite the smaller population size, more large egg-bearing female lobster are found on the Eastern Shore than elsewhere along the Atlantic coast	Miller pers. comm. 2003
Halifax to Lockeport (in lower Shelburne County, SHACI Unit 2)	• Significant area because it constitutes what is probably the most dynamic subtidal ecosystem in the world	Scheibling pers. comm. 2001
Indian Harbour to Pennant Point	• Former herring spawning areas	Trippel 2002
Lawrencetown to Jeddore	• Herring spawning areas	Trippel 2002
Necum Teuch to Canso	• Hake (silver or white) juvenile area (formerly a bigger area)	Trippel 2002
Peggy's Cove to Big Sandy Cove	• Scattered fall herring spawning areas	Clark et al. 1999
Peggy's Cove to Pearl Island	• Important calving habitat for the white-beaked dolphin(April to June)	Gowans pers. comm. 2001
	• Appears to be particularly important for marine mammals	Gowans pers. comm. 2001
Peggy's Cove to Pennant Point	• Herring spawning area	Trippel 2002
Pennant Point to Herring Cove	• Herring spawning area	Trippel 2002
Pennant Point to Owls Head Harbour	• Scattered fall herring spawning areas	Clark et al. 1999
Shiers Pond to Jake Mosers Point, including MacDonald Island and Torpey Island	• Extensive marine flats	NSDNR 2002
St. Margarets Bay and inlets north to Halifax Harbour	• Egg-bearing female American lobsters are three times more abundant compared to southwest Nova Scotia	Miller 1997

Table 23-3: Specific areas and attributes of significance in SHACI Units 4-6

Location	Attribute	Reference(s)
Around Baptiste Island	- Several seal haulout locations	HCESCRMP 1996
Barren Island (NTB)	- Supports Common Eider, Great Black-backed Gull, Great Blue Heron, Herring Gull colonies	Environment Canada 2002a
Bay of Islands	- Salt marsh	Lirette 1988
Bear Cove	- Site of Ecological Significance	NSMNH 1991
Bird Islands	- Supports seabird colonies: Arctic Tern, Common Eider, Common Tern, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel, Razorbill, Roseate Tern, Common/Arctic Tern	Environment Canada 2002a
Black Duck Cove	- extensive marine flats	NSDNR 2002
Blandford	- Provincial Game Sanctuary	
Borgles Island, west of	- Several seal haulout locations	HCESCRMP 1996
Brokenback Island	- Site of Ecological Significance	NSMNH 1991
	- International Biological Programme recognized for its importance as bird habitat	CCIBPCTCS 1974
	- Important Bird Area	BSC 2003a
	- Supports Common Eider, Great Black-backed Gull, Great Blue Heron, Herring Gull, Leach's Storm-Petrel colonies	Environment Canada 2002a
Brother Islands	- Supports Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Cormorant, Leach's Storm-Petrel colonies	Environment Canada 2002a
Calf Island and Low Island, unidentified between	- Supports Roseate Tern colony (endangered species)	Environment Canada 2002a
Camp Island	- Supports Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel colonies	Environment Canada 2002a
Chebucto Head	- Aggregations of large schools of herring in the winter	Melvin et al. 1999, Melvin et al. 2001, Melvin et al. 2004
	- Minke whales are seen year round	Whitehead pers. comm. 2001
	- Herring spawning areas	Trippel 2002
	- Large concentrations of redfish larvae	Breeze et al. 2002 (using data from SSIP)
Cheticumchec Island	- Eastern Habitat Joint Venture Lands	
Chezzetcook Inlet	- Estuarine flats, eelgrass beds, and low and high salt marsh	NSDNR 2002
	- 12 important softshell clam flats	Witherspoon 1982
	- Eastern Habitat Joint Venture Lands (lower East Chezzetcook)	
	- Protected Beach (Lower East Chezzetcook Beach)	Nova Scotia *Beaches Act* 1989
Clam Bay	- Former hake spawning area in October-November (off Clam Bay)	Trippel 2002
	- Salt marsh area	Lirette 1988

Clam Harbour and surrounding area	- Former Piping Plover nesting area (endangered species) on Clam Harbour beach	Lock et al. 1994, Ferland and Haig 2002
	- Supports higher standing stocks of softshell clams than other areas of Nova Scotia	Mullen and Woo 1985
	- Extensive estuarine flats, low salt marsh, marine flats and eelgrass	NSDNR 2002
Clattenburgh Brook	- Nova Scotia Wilderness Area designated to protect the ecosystems of the Quartzite Hills and Plains natural landscape	NSDEL 2003a
Cole Harbour	- Former Piping Plover (endangered species) nesting area	Lock et al. 1994, Ferland and Haig 2002
	- Breeding locations of Great Black-backed Gull, Herring Gull	Tufts 1986, P. Lane and Associates 1992, Lock et al. 1994, BSC 2002, Environment Canada 2002a
	- Supports many shorebird and marsh bird species, including American Golden Plover, Black-bellied Plover , Semipalmated Plover, Sanderling, Willet, Greater Yellow Legs, American Avocet, Ruddy Turnstone, Red Knot, Marbled Godwit	Tufts 1986, Fenton 1993, Lock et al. 1994, Maybank 1995, Davis and Browne 1996, HCESCRMP 1996, BSC 2002, CWS 2002, Environment Canada 2002b & c
	- Has Indian Reserve Lands	
	- Eastern Habitat Joint Venture lands	
	- Extensive estuarine flats, low salt marsh and eelgrass beds	NSDNR 2002
Conrod's Beach	- Former breeding site of endangered Piping Plover	Lock et al. 1994, Ferland and Haig 2002
	- Site of Ecological Significance	NSMNH 1991
	- Protected Beach	Nova Scotia's *Beaches Act* 1989
	- 12 shorebird species recorded in 2001	CWS 2002
Cow Bay	- Estuarine flat, eelgrass beds, coastal saline ponds	NSDNR 2002
Surrounding Deepwater Island, Table Island, Rack Island, Duck Rock, The Finger, Little Goose Island and Anns Island	- Extensive marine flats	NSDNR 2002
Duncan's Cove	- Site of Ecological Significance	NSMNH 1991
	- Nature Reserve	Province of Nova Scotia 2004
Duck Island	- Supports Common Eider, Double-crested Cormorant, Great Black-backed Gull, Herring Gull colonies	Environment Canada 2002a
Eastern Passage	- Herring spawning area	Stephenson et al. 2000, Melvin et al. 2001, DFO 2002b, Melvin et al. 2003, Melvin et al. 2004
Eastern Shore Islands	- Scattered occurrences of Harlequin Ducks overwintering population (approx. 50 individuals) (species of special concern)	Lock et al. 1994, Butler pers. comm. 2003, IBA Canada 2003
	- Provincial Wildlife Management Area (Eastern Shore Islands Wildlife Management Area)	

	• Supports breeding populations of the Atlantic Puffin, Leach's Storm-Petrel	Tufts 1986, P. Lane and Associates 1992, Lock et al. 1994, Chardine 1999, BSC 2002, Environment Canada 2002a
	• Important Bird Area for its globally and continentally significant Common Eider, and nationally significant Harlequin Duck populations (species of special concern)	BSC 2003a
Ecum Secum	• Supports high populations of harbour seals	Boulva and McLaren 1979, Bowen and Harrison 1996
False Passage (between Cable Island and Wolfes Island)	• Extensive marine flats	NSDNR 2002
Fisherman's Beach	• Roseate Tern nesting area (endangered species)	Environment Canada 2002a
Francis Nose Island	• Eastern Habitat Joint Venture Lands	
Frostfish Cove	• Extensive estuarine flats	NSDNR 2002
Goose Point	• Eastern Habitat Joint Venture Lands	
Gravel Island	• Supports Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull colonies	Environment Canada 2002a
Guilford Island	• Supports Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull colonies	Environment Canada 2002a
Gulf Ledge	• Supports cormorant spp., Great Black-backed Gull, Leach's Storm-Petrel, Common/Arctic Tern colonies	Environment Canada 2002a
Gunner Island	• Eastern Habitat Joint Venture Lands	
Hacketts Cove	• Extensive marine flats	NSDNR 2002
Halibut Islands	• Supports Common Eider, Cormorant spp., Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull, Leach's Storm-Petrel colonies	Environment Canada 2002a
Halifax Harbour and its approaches (including Chebucto Head, Sambro ledges)	• Frequented by enough whales to support whale watching operations	
	• Highly productive autumn spawning area for cod (Maritime population, species of special concern)	McKenzie 1940
	• Herring spawning area	Clark et al. 1999
	• Fall spawning of cod (species of special concern) in the inshore areas near, and west of, Halifax	Brander and Hurley 1992
	• Cod larvae were abundant off Halifax in November and December	Gagné and O'Boyle 1984
	• Regularly visited by minke whales (*Balaenoptera acutorostrata*), fin whales (species of special concern), harbour porpoises (species of special concern), white-beaked dolphins (*Lagenorhynchus albirostris*), and white-sided dolphins (*Lagenorhynchus acutus*)	Whitehead pers. comm. 2001

	• Extensive marine flats (along South East Passage)	NSDNR 2002
	• Fin whales (species of special concern) are found during both summer and winter seasons	Whitehead pers. comm. 2001
	• Supports a local inshore population of cod (species of special concern) from early fall to early winter	DFO 2003, Fanning pers. comm. 2003
	• Approximately 30 Harlequin Ducks (species of special concern) are regularly observed off Halifax during the winter	Lock et al.1994, Butler pers. comm. 2003
	• Former pollock spawning areas	Trippel 2002
Hardwood Island	• Supports Roseate Tern (endangered species) colony	Environment Canada 2002a
Harbour Islands	• Supports Common Eider, Great Black-backed Gull, Leach's Storm-Petrel, Herring Gull colonies	Environment Canada 2002a
Hollahan Lake	• Site of Ecological Significance	NSMNH 1991
Horse Island	• International Biological Programme recognized for its importance as bird habitat	CCIBPCTCS 1974
	• Important Bird Area	BSC 2003a
	• Site of Ecological Significance	NSMNH 1991
	• Supports Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull colonies	Environment Canada 2002a
Indian Harbour	• Extensive estuarine flats	NSDNR 2002
Indian Island & associated islets	• Eastern Habitat Joint Venture Lands	
Jeddore Harbour	• Juvenile haddock area	Trippel 2002
	• Extensive estuarine flats and eelgrass beds	NSDNR 2002
Kidston Lake	• Site of Ecological Significance	NSMNH 1991
Kirby River	• Extensive estuarine flats	NSDNR 2002
Lawrencetown	• Salt marsh	NSDNR 2002
Lawrencetown Lake	• Estuarine flats, coastal saline pond and eelgrass beds	NSDNR 2002
Lawrencetown Beach	• Protected Beach	Nova Scotia *Beaches Act* 1989
	• Extensive marine flats	NSDNR 2002
Little White Island	• Supports Common Eider, Cormorant spp., Double-crested Cormorant, Great Black-backed Gull, Great Cormorant, Herring Gull, Leach's Storm-Petrel colonies	Environment Canada 2002a
	• Site of Ecological Significance	NSMNH 1991
	• Important Bird Area	BSC 2003a
	• International Biological Programme recognized for its importance as bird habitat	CCIBPCTCS 1974
Little Island Point	• Extensive estuarine flats	NSDNR 2002
Long Island (BH)	• Supports Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull, Leach's Storm-Petrel, Common/Arctic Tern colonies	Environment Canada 2002a
	• Site of Ecological Importance	NSMNH 1991
	• Important Bird Area	BSC 2003a

	• International Biological Programme recognized for its importance as bird habitat	CCIBPCTCS 1974
Long & Gulch Island, between	• Supports Roseate Tern (endangered species) colony	Environment Canada 2002a
Marrs Island	• Extensive marine flats (eastern coast)	NSDNR 2002
Martinique Beach	• Provincial Game Sanctuary	
	• Breeding site of endangered Piping Plover	Lock et al. 1994, HCESCRMP 1996, Ferland and Haig 2002
McCormack's Beach	• Protected Beach	Nova Scotia *Beaches Act* 1989
Mill Cove	• Extensive marine flats	NSDNR 2002
Moser River	• pH levels suitable for Atlantic salmon production	O'Neil et al. 1998
Musquodoboit Harbour area	• Ramsar Site (outer estuary)	Environment Canada 2003
	• Least Bittern (threatened species)	
	• Extensive estuarine flats, salt marsh, eelgrass	NSDNR 2002
	• Eastern Habitat Joint Venture lands	
	• Important Bird Area for its continentally significant populations of Canada Geese and American Black Duck	BSC 2003b
Musquodoboit River	• pH levels suitable for Atlantic salmon production	O'Neil et al. 1998
Necum Teuch	• Supports Roseate Tern (endangered species) colony on gravel bar	Environment Canada 2002a
	• Former pollock spawning area • Former haddock spawning area	Trippel 2002
Nelson Conservation Area	• Eastern Habitat Joint Venture Lands	
Noonan's Beach	• Protected Beach	Nova Scotia *Beaches Act* 1989
Outer Island (SH)	• Supports Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron colonies	Environment Canada 2002a
The Pancake	• Supports Common Eider, Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull colonies	Environment Canada 2002a
Pearl Island	• Breeding location for Atlantic Puffin, Razorbill, Black Guillemot and Leach's Storm-Petrel, Great Black-backed Gull, Herring Gull, Great Cormorant, Arctic Tern, Common Tern	Tufts 1986, P. Lane and Associates 1992, Lock et al. 1994, BSC 2002, Environment Canada 2002a
Peggy's Cove	• Peggy's Cove Preservation Area	*Peggy's Cove Commission Act* 1963
	• William E. Degarthe Provincial Park	*Provincial Parks Act* 1989
	• Several seal haulout locations	HRMWRCRMP 1996
Peter McNab Kuhn Conservation Area	• Eastern Habitat Joint Venture Lands	
Petpeswick Inlet	• Extensive marine flat, eelgrass and low salt marsh	NSDNR 2002
Phoenix Island to Sheet Harbour	• Several seal haulout locations	HCESCRMP1996
Prospect	• Least Bittern (threatened species)	
	• Estuarine flats	Lirette 1988

Pumpkin Island	• Supports Black Guillemot, Common Eider, Double-crested Cormorant, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel colonies	Environment Canada 2002a
	• Site of Ecological Importance	NSMNH 1991
	• Important Bird Area	BSC 2003a
	• International Biological Programme recognized for its importance as bird habitat	CCIBPCTCS 1974
Queensland Beach	• Extensive marine flats	NSDNR 2002
Queensport Beach	• Protected Beach	Nova Scotia *Beaches Act* 1989
Quoddy, unidentified off	• Supports Roseate Tern (endangered species) colony	Environment Canada 2002a
Quoddy Hill	• Extensive marine flats (south and east of Quoddy Hill, extending over to the Eastern Shore Islands Wildlife Management Area)	NSDNR 2002
Ram Island near Orkney	• Supports Common Eider, Great Black-backed Gull, gull spp., Herring Gull, Common/Arctic Tern colonies	Environment Canada 2002a
The Run (between Tangier Island and Baltee Island)	• Extensive marine flats	NSDNR 2002
Sambro Basin	• Extensive estuarine flats	NSDNR 2002
Sambro Island	• Roseate Tern nesting area (endangered species)	Environment Canada 2002a
	• Supports seabird colonies: Great Black-backed Gull, Herring Gull, Common/Arctic Tern	
Sand Bay	• Extensive marine flats	NSDNR 2002
Sandy Island (BH)	• Supports Common Eider, Great Black-backed Gull, Herring Gull, Common/Arctic Tern colonies	Environment Canada 2002a
Sellars Cove	• Extensive estuarine flats	NSDNR 2002
Sheas Island	• Extensive estuarine flats	NSDNR 2002
Ship Harbour	• Extensive estuarine flats	Lirette 1988
Sober Island	• Marine flats (on Back Beach) and coastal saline pond	Lirette 1988, NSDNR 2002
Southwest Island (NS)	• Supports Double-crested Cormorant, Great Black-backed Gull, Great Blue Heron, Herring Gull colonies	Environment Canada 2002a
Speck Island	• Supports Common Eider, Cormorant spp., Double-crested Cormorant, Great Black-backed Gull, Great Cormorant, Herring Gull colonies	Environment Canada 2002a
St. Margarets Bay and surrounding waters	• Regularly visited by minke whales, fin whales (species of special concern), harbour porpoises (species of special concern), white-beaked dolphins, and white-sided dolphins	Gowans pers. comm. 2001
	• Frequented by enough whales to support whale watching operations	
	• Mouth of St. Margarets Bay is important calving habitat for the white-beaked dolphin (April to June)	Gowans pers. comm. 2001

	• Shallow waters off Blandford are preferred area for Northwest Atlantic harbour porpoise (species of special concern) in early summer	Eddy 2001, Gowans pers. comm. 2001
	• Highly productive autumn spawning areas for cod	McKenzie 1940, Trippel 2002
	• Pollock juvenile area	Trippel 2002
	• Former pollock spawning areas	Trippel 2002
	• Spring/summer mackerel spawning area	Grégoire et al. 1999, Bernier and Lévesque 2000
	• Potentially significant area for marine plants	Scheibling pers. comm. 2001
St. Mary's River	• Extensive estuarine flats	Lirette 1988
Sutherland Island (east of)	• Extensive marine flats	NSDNR 2002
Tangier Grand Lake	• Nova Scotia Wilderness Area designated to protect Nova Scotia's Eastern Shore Granite Ridge natural landscape	NSDEL 2003b
Taylors Head Bay	• Extensive marine flats	NSDNR 2002
Terence Bay	• Coastal saline ponds	NSDNR 2002
	• Nova Scotia Wilderness Area designated to protect Nova Scotia's Pennant Coastal Barrens natural landscape	NSDEL 2003c
Three Fathom Harbour and surrounding areas	• Supports higher standing stocks of softshell clams than other areas of Nova Scotia	Mullen and Woo 1985
	• Extensive marine flats, eelgrass beds, coastal saline ponds	NSDNR 2002
Thrumcap Island (NTB)	• Supports Arctic Tern, Common Eider, Common Tern, Great Black-backed Gull colonies	Environment Canada 2002a
Thrum Cap Islet	• Supports Roseate Tern (endangered species) colony	Environment Canada 2002a
Tobacco Island	• Supports Common Eider, Cormorant spp., Great Black-backed Gull, Great Blue Heron colonies	Environment Canada 2002a
Waverly Game Sanctuary	• Provincial Game Sanctuary	
Waverley Salmon River - Long Lake	• Nova Scotia Wilderness Area	NSDEL 2003d
Wedge Island	• Supports Arctic Tern, Cormorant spp., Common Tern, Great Black-backed Gull, Herring Gull, Roseate Tern (endangered species), Common/Arctic Tern colonies	Environment Canada 2002a
Wedge Island to Gaetz Head	• Extensive marine flats	NSDNR 2002
West Dover	• Site of Ecological Significance	NSMNH 1991
	• International Biological Programme	CCIBPCTCS 1974
West Marsh	• Extensive estuarine flats and eelgrass beds	NSDNR 2002

Western Island (NS)	- Supports Roseate Tern (endangered species) colony	Environment Canada 2002a
White Islands	- Supports Common Eider, Great Black-backed Gull, Herring Gull, Leach's Storm-Petrel, Great Blue Heron colonies	Environment Canada 2002a
White Lake	- Nova Scotia Wilderness Area representing the Eastern Shore Granite Ridge landscape	NSDEL 2003e

Areas identified as significant habitats

Chezzetcook Inlet

Chezzetcook Inlet has a diversity of wetland habitats, including estuarine flats (841 ha), eelgrass beds, low and high salt marsh (219 ha) and coastal saline ponds (50 ha) (Lirette 1988, NSDNR 2002). There are twelve important softshell clam flats in the area (Witherspoon 1982). One hundred and thirty hectares (130 ha) of Lower East Chezzetcook are Eastern Habitat Joint Venture Lands. Lower East Chezzetcook Beach is a Protected Beach.

Clam Harbour/Clam Bay

Clam Harbour has a diversity of wetland habitats, including estuarine flats (326 ha), marine flats, salt marsh (112 ha), eelgrass and coastal saline ponds (72 ha) (Lirette 1988, NSDNR 2002). The Harbour supports higher standing stocks of softshell clams than other areas of Nova Scotia (Mullen and Woo 1985). Although Clam Harbour Beach was a nesting area for the endangered Piping Plover (Lock et al. 1994), no breeding pairs were found there in 2001 (Ferland and Haig 2002). There was once a hake spawning area off Clam Bay in October-November (Trippel 2002).

Cole Harbour

Cole Harbour encompasses a dynamic wetland system. Eighty percent (80%) of the area is comprised of estuarine flats (Table 23-4) and dominated by eelgrass (69%) (Table 23-5).

Table 23-4: Area of wetland types in Cole Harbour wetland system (Austin-Smith et al. 2000)

Wetland type	Area (ha)
Estuarine flats	765.21
Salt marsh	158.00
Dune	18.79
Ponds	8.78
Marine flats	7.34
Total	958.12

Table 23-5: Area of dominant vegetation in Cole Harbour wetland system (Austin-Smith et al. 2000)

Dominant vegetation	Area (ha)
Grass (Marram grass)	18.79
High marsh (*S. patens*)	20.49
Low marsh (*S. alterniflora*)	137.51
Eelgrass (*Z. marina*)	605.14
Total	871.93

The various wetland components of Cole Harbour provide important habitats for many birds. The Cole Harbour site is a significant bird area for the Willet, Great Blue Heron and the endangered Piping Plover (Lock et al. 1994), although in 2001 there were no breeding pairs of Piping Plovers in the area (Ferland and Haig 2002). Many other shorebirds and marsh birds also frequent the area. Several seabirds, including the Herring Gull and Great Black-backed Gull, breed in the area (Environment Canada 2002a). Cole Harbour is one of the preferred locations of the Canada Goose along Nova Scotia's coast (Lock et al. 1994, Davis and Browne 1996). The Harbour is a former herring spawning area (Trippel 2002).

The Cole Harbour wetland system is a valued area with a variety of coastal habitats that are used for recreation (e.g., bird watching, swimming, trail walking) and clam harvesting. The area was officially designated the Cole Harbour/Lawrencetown Coastal Heritage Park System in 1998 under the *Provincial Parks Act* 1989. Within the Park System, Rainbow Haven Beach is a Provincial Park. In the Cole Harbour area, there are two Eastern Habitat Joint Venture lands: Peter McNab Kuhn Conservation Area (1919 ha) and the Nelson Conservation Area (164 ha). Cole Harbour has one of only two Indian Reserve Lands located near HRM's Atlantic shore. The Cole Harbour Reserve (18.6 ha) is one of four land holdings that comprise the Millbrook Reserve, which is occupied by the Millbrook First Nation community, part of the Mi'kmaq Nation (Millbrook First Nation 2003).

Conrod's Beach

Conrod's Beach was a nesting site of the endangered Piping Plover (Lock et al. 1994), although in 2001 there were no breeding pairs found there (Ferland and Haig 2002). The beach is protected under the *Beaches Act* and is considered a Site of Ecological Significance (NSMNH 1991). In 2001, twelve shorebird species were recorded on Conrod's Beach (CWS 2002). This beach is arguably the most significant shorebird area in SHACI Units 4-6.

Eastern Shore Islands

The Eastern Shore Islands are located between 60 and 120 km east of Halifax, and include inshore islands roughly between Clam Harbour and Ecum Secum (BSC 2003a). This area has many low islands, islets and reefs from 2-15 km offshore. The area was designated an Important Bird Area for its globally and continentally significant Common Eider, and nationally significant Harlequin Duck populations (species of special concern) (BSC 2003a).

Part of the Eastern Shore Islands are designated a Provincial Wildlife Management Area. The Eastern Shore Islands Wildlife Management Area (ESIWMA) includes approximately 50 vegetated islands and islets, and 10 non-vegetated islets or ledges located roughly between Beaver Harbour and Ecum Secum (Payne 1977). The ESIWMA protects the islands, ledges and reefs within the area from undue human disturbances.

Within the ESIWMA, five rugged and undisturbed islands located at the outer margin of the Bay of Islands (Brokenback, Horse, Little White, Long and Pumpkin Islands) are recognized for their importance as bird habitat by several organizations. The International Biological Programme recognizes the important bird nesting sites, particularly for the Black Guillemot, Common Eider, Double-crested Cormorants, Fox Sparrow, Leach's Storm Petrel and Osprey, as attributes of exceptional interest (CCIBPCTCS 1974). The islands are also recognized as Important Bird Areas (BSC 2003a) and Sites of Ecological Significance (NSMNH 1991).

Halifax Harbour

Halifax Harbour is a busy commercial port but also has many significant ecological attributes. It is frequented by enough whales to support whale watching operations. The Harbour and its approaches are regularly visited by minke whales, fin whales (species of special concern), harbour porpoises (species of special concern), white-beaked dolphins, and white-sided dolphins (Whitehead pers. comm. 2001).

The Harbour is a highly productive autumn spawning area for cod (Maritime population, species of special concern) (McKenzie 1940), particularly in inshore waters near and east of Halifax (Brander and Hurley 1992). The area supports a local inshore population of cod from early fall to early winter (DFO 2003, Fanning pers. comm. 2003). The area is a known herring spawning area (Clark et al. 1999) and former pollock spawning area (Trippel 2002). Approximately 30 Harlequin Ducks (species of special concern) are regularly observed off Halifax during the winter (Lock et al.1994, Butler pers. comm. 2003). Extensive marine flats occur along South East Passage (NSDNR 2002).

Musquodoboit Harbour area

Musquodoboit Harbour (Unit 5) is a long, narrow estuary consisting of a system of extensive estuarine and marine flats, eelgrass beds and salt marshes. The inner tidal area is protected from the sea by a 5 km long sandspit, fringed in places by salt marsh. Rapid tidal flow into the western arm behind the beach and the eastern main Musquodoboit River portion maintains eelgrass and sand flats free of ice for wintering waterfowl except under the most severe weather conditions (Environment Canada 2003). The mudflats support extensive eelgrass beds and an abundance of invertebrates, providing food for numerous migratory waterbirds, such as the 3000 Green-winged Teal, that use the area during fall migration (Environment Canada 2003). Numerous staging shorebirds also use the area during the autumn migration, mainly from late July to September.

The estuary in Musquodobit Harbour is designated an Important Bird Area for its continentally significant populations of Canada Geese and American Black Duck (BSC 2003b). It is one of the most important coastal staging sites for Canada Geese (6000 birds) and American Black Ducks (3000 birds) and supports the largest wintering population of these two species in Atlantic Canada.

The outer estuary is designated a RAMSAR site, one of only eight such sites located throughout the Atlantic provinces and the only one within SHACI's geographic domain (Environment Canada 2003). The site covers approximately 1925 ha and is composed of eelgrass, sand and mud flats, sand beaches and beach grass, intertidal estuarine waters and marshes, as well as scattered upland islands (Table 23-6). The site is a highly significant coastal landscape with high recreational use, threatened by naturally eroding sand dunes that protect it from the open ocean and inland development (Environment Canada 2003).

Table 23-6: Coastal habitats of the Musquodoboit Harbour wetland system (Environment Canada 2003)

Coastal habitat	Percent of total area (%)	Area (ha)
Eelgrass beds	30	648
Salt marsh with *Spartina* sp.	11	206
Upland islands	21	404
Sand beach, sand and mud flats	17	327
Tidal waters at low tide	17	317
Beach grass (*Ammophila breviligulata*)	1	23

In the outer estuary, Martinique Beach creates a barrier between the Atlantic Ocean and the protected lagoon and marshes behind, and is one of the largest crescent beaches in Nova Scotia. Martinique Beach is designated a Provincial Game Sanctuary and a Provincial Park, and is a breeding site for the endangered Piping Plover (Lock et al. 1994, Ferland and Haig 2002). The RAMSAR site overlies both the Martinique Beach Provincial Park and Game Sanctuary.

Key habitat areas outside the Provincial Park and Game Sanctuary are protected through the Eastern Habitat Joint Venture program. These lands were secured via purchase or donation under the auspices of the North American Waterfowl Management Plan: Francis Nose Island (188 ha), Gunners Island (37 ha), Indian Island and associated islets (30 ha), Cheticumchee Island (27 ha) and Goose Point Island (2.4 ha).

Another feature of the Musquodoboit area is the health of the Musquodoboit River. The Musquodoboit River is one of only two rivers in SHACI Units 4-6 that has pH levels suitable for Atlantic salmon production (O'Neil et al. 1998), and is a favourite location for canoeing.

St. Margarets Bay and surrounding waters

St. Margarets Bay is relatively unpolluted. The area is frequented by enough whales to support whale watching operations. The bay is regularly visited by minke whales, fin whales (species of special concern), harbour porpoises (species of special concern), white-beaked dolphins, and white-sided dolphins (Gowans pers. comm. 2001). The mouth of St. Margarets Bay is important calving habitat for the white-beaked dolphin (April to June) and shallow waters off Blandford are a preferred area for Northwest Atlantic harbour porpoises (species of special concern) in early summer (Eddy 2001, Gowans pers. comm. 2001).

St. Margarets Bay is a highly productive autumn spawning area for cod (Maritimes population, species of special concern) (McKenzie 1940, Trippel 2002) and a mackerel spawning area in spring/summer (Grégoire et al. 1999, Bernier and Lévesque 2000). The Bay is also a pollock juvenile area and former pollock spawning areas existed in the area (Trippel 2002). Another attribute of this area is that egg-bearing female American lobsters are three times more abundant in St. Margarets Bay and inlets north to Halifax Harbour compared to southwest Nova Scotia (Miller 1997).

St. Margarets Bay is known to have eelgrass beds in sheltered inlets at the head of the Bay, and on the sheltered side of islands, at depths of 2-5 m and typically on muddy substrates (Mann 1972). There are two estuarine flats in the bay, comprising 138 ha (Lirette 1988). Scheibling (pers. comm. 2001) proposed St. Margarets Bay as a potentially significant area for marine plants on the basis that macroalgae are highly productive in this inlet.

Other significant habitats

Several locations can be considered significant habitat because they support colonies of the endangered Roseate Tern. These areas are (Environment Canada 2002a):

- Western Island
- An area off Quoddy
- An area between Long and Gulch Islands
- Inner west Bird Islands
- Hardwood Island
- Thrum Cap Islet
- Wedge Island

An area between Calf Island and Low Island

- Fisherman's Beach

A gravel bar off Necum Teuch

- Sambro Island

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